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A N
INTRODUCTION
T O T H E
U S E of the G L O B E S,
A N D T H E
O R R E R Y:

As also the Application of Astronomy to Chronology, in which are contained Rules and Memorial Canons for finding the *Dominical Letter*, *Leap-Year*, *Epaet*, *Easter*, &c. according to the Gregorian Account or New Style, with an Explication of the Reason of each Rule.

Adapted to the
INSTRUCTION and ENTERTAINMENT of
such Persons as are not previously versed in
Mathematic Science.

W I T H A N
A P P E N D I X,

Attempting to explain the Account of the First and Fourth Days Work of CREATION in the First Chapter of *Genesis*.

By DAVID JENNINGS, D. D.

L O N D O N:

Printed for J. NOURSE, at the *Lamb*, facing *Catherine-Street* in the *Strand*; J. OSWALD, at the *Rose* and *Crown* in the *Poultry*, near the *Mansion-House*; and J. BUCKLAND, at the *Buck* in *Pater-noster Row*, near *St. Paul's*.

MDCCLII.





P R E F A C E.



THE Persons for whose Sake and Use the following Treatise was at first drawn up, (or rather, I should say, as to the bigger Part of it, this Collection was made out of many other and bigger Books) are chiefly such, who, tho' they have not the Opportunity of attending to the more abstruse Parts of Mathematic Science, are desirous of, at least, some general Knowledge of these Matters; such who, tho' Providence has marked out their Track of Life thro' Scenes of worldly Business, yet have Souls large enough to extend themselves, now and then, beyond this little Planet, and to take a distant View of other remote Worlds; in the Contemplation of which, both the philosophic and pious Mind may find its Account, for Entertainment and Profit. *The Works of*

the Lord are great, sought out of all them that have Pleasure therein.

I have endeavoured to keep my Readers of this sort every where in View; and I hope nothing will be found here which is above their Reach; except, perhaps, in the Ninth and Tenth Chapters of the Second Part; where, indeed, the Reader is supposed to have a little previous Knowledge of the Doctrine of *Angles*: But that is so little, and may be so presently attained, that it need hardly be mentioned as an Exception to my general Design, of writing for the Instruction of the Unlearned.

The Method in which I have handled the Doctrine and Use of the Globes, in the first Part, is somewhat singular. For most, if not all other Writers on that Subject, have treated on both Globes, as preparatory even to learning Geography; whereby, methinks, they have made the Threshold to that Science, a great deal higher than it need be. I see no Occasion to perplex a young Mind with *Right* and *Oblique Ascension*, and *Descension*, and *Ascensional Difference*, and many other puzzling Matters, which have no Relation to Geography, before he can be led into an Acquaintance with Lands and Seas, and Kingdoms and Provinces. I have, therefore, in the first Place, explained the Terrestrial Globe only, as if there were no such Thing

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Thing as a Celestial one; after which I would propose that the young Student should read some System of Geography, before he proceeds to the Celestial Globe.

For the Use of the Globes I have given only Twenty Problems, out of a Multitude that may be found in almost any Book on that Subject: But I conceive these Twenty are so far sufficient, that if a Person is Master of them, he will be able readily to work any that he meets with in other Books. The best Collection of this Sort, that I know of, is in Dr. *Watts's Knowledge of the Heavens and Earth made easy*; to which, therefore, I would refer the Learner, for his further Practice and Entertainment.

A good deal of the Second Part is adapted to *the Use of the Orrery*, for which Purpose it was drawn up; and, perhaps, an Instrument of that Sort may be needful to illustrate some of the Chapters, and to render them easily intelligible, to such Persons whose Instruction is here chiefly aimed at. However I would propose the following cheap and easy Contrivances to those who are not furnished with that noble Instrument; which may serve tolerably well instead of it.

To help the Imagination to conceive of the double Motion of the Earth, viz. its annual Motion round the Sun, and its diurnal

urnal Motion on its own Axis. Take a round Ball, or Globe, of an Inch or more Diameter, made of Ivory, or some other pretty heavy Substance, to represent the Earth; let it be painted half black, and half White; fix a Hook, or little Staple, any where in the Circle that divides the Black from the White Hemisphere; tie a String to it, of two Feet, or more, in Length; twist the String, so that when it is let go, and the Ball suspended by it, it will untwist, and thereby turn the Ball swiftly round; then holding the End of the String directly over a Candle (to represent the Sun) so that the Ball may hang as low as the Flame of the Candle, give it a circular Motion round the Candle, to represent the Motion of the Earth round the Sun; and the untwisting of the String will, at the same Time, give it a Motion round its Axis, representing the diurnal Motion of the Earth. The Use of painting the Globe Black and White, in this Experiment, is to make the diurnal Motion visible, which otherwise, when the Ball moves swiftly round, would hardly be seen.

Again, to help the Imagination to conceive, how the annual Motion of the Earth occasions the lengthening and shortening of Days, and the Change of Seasons. Take another Ball, or Globe, of about two, or three, Inches Diameter, let it be painted

painted all over White ; only let the Poles be marked upon it, and the Equator, Tropics, and Polar Circles, be drawn with Black ; make a Spot also to mark the Latitude of any given Place, (suppose *London* ;) let a Hole be bored thro' the Globe from Pole to Pole, into which put a Spindle, or Axis, on which it may turn round. Then setting a Candle directly before you, on a Table, in a darkened Room, hold the Axis of the Globe, (which must, therefore, be longer than its Diameter, in order to your holding the Globe upon it,) not perpendicular to the Table, but inclined to it in an Angle, as near as you can guess, of $66\frac{1}{2}$ Degrees ; and let the Globe be held as high from the Table as the Flame of the Candle. Then, first, hold the Globe with its North Pole from you, at a Distance from the Candle, on the left Hand of it ; so that the Circle of Illumination may pass thro' both Poles : It then represents the Position and Place of the Earth at the *Vernal Equinox*. Then move the Globe towards you, in a Circle parallel to the Table, observing to keep the Axis in the same Inclination, and always parallel to itself, or pointing the same Way ; when the Globe is brought directly betwixt you and the Candle it represents the Position and Place of the Earth at the *Summer Solstice* ; and then, if the Axis of the Globe is duly inclined

inclined to the Table, the enlightened Hemisphere will just take in the whole Northern Frigid Zone. Carry on the Globe to the right Hand of the Candle, directly opposite to the Place where you held it at first, and it will represent the *Autumnal Equinox*; when it is moved to be directly beyond the Candle, it represents the *Winter Solstice*. And, by turning the Globe on its Axis, in several Parts of the Circle, in which it is moved round the Candle, you will see how the Days lengthen and shorten in that Place, whose Latitude is marked upon it. Perhaps it may be of some Use to draw a Circle with Chalk, upon the Table, round the Candle, as its Center, over which you are to move the Globe. Or a Circle made of Wood, Pastboard, or Paper, divided and marked with the twelve Signs of the Zodiac, and laid upon the Table, may do still better.

By Means of this Globe, and the other Black and White one, now to represent the Moon, (which should therefore be made less than the Earth,) the Phases of the Moon may be shewed in the several Parts of her Orbit round the Earth. Let the white Hemisphere represent that Hemisphere, and Face of the Moon, which is always obverted to the Earth; and the Light of the Candle will shew how much
of

of that Hemisphere is enlightened, by the Sun, in every Part of her Orbit.

Again, by Means of these two Globes, the Doctrine of Eclipses, and of the Tides, may be tollerably well illustrated.

And if the lesser Globe be carried round the Candle, either further off than the Earth, to represent a superior Planet ; or nearer, to represent an inferior one ; it may easily be shewed, how the Planets will at sometimes appear Westward of the Sun, and sometimes Eastward ; and, consequently, how they are sometimes Morning Stars, and sometimes Evening Stars to the Earth.

In the Third Part of the ensuing Treatise, which shews the Application of Astronomy to Chronology, I have inserted several memorial Canons, adapted to the Gregorian Style, for most of which I am obliged to Mr. *John Canton*, M. A. and F. R. S. all those, and the Explications of them, which are marked with an Asterism are His.

The Hypothesis in the Appendix is, for ought I know, entirely new. I offer it as an Hypothesis. It is Satisfactory to my own Mind ; whether it will appear so to others, I must leave with my Readers.



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APPENDIX, attempting to Explain the Account of the First and Fourth Days Work of Creation, in the First Chapter of GENESIS.

An EXPLICATION of some Algebraic, and other Characters, used in this Book.

= Is the Sign of Equality, and is read *equal*, as $3 = 3$ and $2 = 5$, signifies 3 and 2 are equal to 5.

+ Is the Sign of Addition, and is read *plus* or *more*, as $4 + 2$, signifies 4 more 2, or 2 added to 4, $= 6$.

— Is the Sign of Subtraction, and is read *minus* or *less*, as $9 - 2$ signifies 9 less 2, or 2 subtracted from 9, $= 7$.

× Is the Sign of Multiplication, as 4×3 signifies 4 multiplied by 3, $= 12$

÷ Is the Sign of Division, as $12 \div 3$ signifies 12 divided by 3, $= 4$.

Degrees are sometimes expressed by a little Circle over the right Hand Corner of a Figure, as 5° stands for 5 Degrees.

Minutes, by a single Stroke, as $5'$ stands for 5 Minutes.

Seconds, by 2 Strokes, as $5''$ stands for 5 Seconds.

E R R A T A.

Page 4 in the Marginal Note; Line 5, for from read form. p. 48, l. 9, for Days r. Degrees. p. 52, l. 5, from the Bottom, for foreign Countries, r. most Countries of Europe. p. 53, l. 14, r. 21st. p. 54, l. 13, r. 23d. p. 60, l. 29, r. Equinoctial. p. 63 in the Note, l. 1, for as r. at. p. 79, l. 15, for but the Moon's Attraction is much stronger, r. but is different in different Parts of it, which Difference is much the most considerable in the Moon's Attraction. p. 96, l. 1, fr taken r. take p. 109, l. 16, for 4th r. 15th. p. 141, l. 2, dele And. Appendix, p. 149, l. 4, r. mundane. p. 151, l. 21. for as was r. was as. p. 156, l. 7, r. Equator. p. 162, l. 17, f. r. io r. to. in the Index, l. 2, for 143 r. 147.

THE





PART I.

The Doctrine and Use of the GLOBES.

CHAPTER I.

A Description of the Globes; particularly of the Terrestrial Globe, its Points and Circles.



GLOBE or Sphere signifies a round Body, every Part of whose Surface is equally distant from its Center.

By THE GLOBES, which we are now to treat of, we mean two such artificial spherical Bodies, one of which is supposed to represent the Earth, and the other the Heavens, as visible by Observation. The former is called the *Terrestrial* or *Terraqueous* Globe, the latter the *Celestial*.

B

Half

2 . *The Terrestrial GLOBE,* Part I.

Half a Globe or Sphere is called a *Hemisphere*.

The Terrestrial Globe is an artificial Representation of the natural Earth, having the whole Surface of the Land and Sea drawn upon it, in their natural Form, Order, and Situation.

The Spindle on which the Globe turns is called its *Axis*; which in the artificial Globe is real, in the natural only imaginary.

The two extreme Points of the Earth's Axis are its *Poles*, viz. the North, called the *Arctic*; and the South, called the *Antarctic*.

The Earth is supposed to be surrounded with several imaginary Circles, which are either drawn upon the artificial Globe, or expressed by the Wooden and Brass Work about it.

These Circles are distinguished into *Greater*, and *Lesser*. The *greater* Circles divide the Globe into two equal Parts, the *lesser* into unequal.

Of the Greater Circles, viz. the Horizon, the Equator, Meridians, and the Ecliptic.

I. The HORIZON, which is expressed by the upper Surface of the wooden Circle in which the Globe stands, divides the Globe into an upper and lower Hemisphere.

This



This is called the *Rational Horizon*, to distinguish it from the *sensible* or *apparent Horizon*, which bounds our Prospect all round us, and which is greater or less, according as we stand higher or lower. For Example, an Eye placed at five Feet above the Surface of the Earth or Sea, sees two Miles and a Quarter every way: but if it be at twenty Feet high, it can see five Miles and three Quarters.

The Rising and Setting of the Sun and Stars properly respects the Rational Horizon; that is, they rise when they get above it, and set when they sink below it: But, by reason of their vast Distance from us, the Rational and sensible Horizon are to be considered, in this Case, as one and the same.

The wooden Horizon of the Globe has several Circles drawn upon it. The outermost is marked with the Points of the Mariners Compass; of which the *East*, *West*, *North*, and *South*, are called the *Cardinal Points*, dividing the Horizon into four Quarters. Each of these Quarters is subdivided into eight Points, in all thirty-two. These are also called *Rumbs*; and Lines drawn from any Point upon the Surface of the Globe towards the several Rumbs, are called *Rumb Lines*. The other Circles upon the Horizon will be considered afterwards.

II. The EQUATOR divides the Globe into the Northern and Southern Hemispheres. This is what Sailors call *The Line*; and when they pass over it at Sea, they are said to *cross the Line*. From this Line the Degrees of *Latitude* are counted towards the Poles, viz. 90 towards each Pole *.

III. Semicircles reaching from Pole to Pole, and cutting the Equator at right Angles, are called MERIDIANS. 360 such Semicircles, drawn at equal Distances, quite round the Globe, mark the Degrees of *Longitude*, which are numbered upon the Equator, and are counted from the first Meridian.

The Meridian which passes through *Fero*, one of the *Canary Islands*, is generally

* Every Circle, whether Great or Small, is supposed to be divided into 360 Degrees. Two Lines drawn from any two Points in the Circle to the Center (except two Points that lie in a strait Line with the Center, *Fig. 1.* as A and E) from an Angle at the Center, which is called an Angle of so many Degrees, as are contained in the Arch of the Circle betwixt the two Points. Thus an Angle of 90 Degrees, or right Angle, is measured by $\frac{1}{4}$ of the Circle; an Angle of 45° by $\frac{1}{8}$. A C B is an Angle of 90°, B C D 45°, A C D 135°. N. B. A Degree is divided into 60 Minutes, a Minute into 60 Seconds, a Second into 60 Thirds, &c.

So much as any Angle, or Arch of a Circle, wants of 90 Degrees, is called the *Compliment* of that Angle or Arch; as D E is the Compliment of the Arch B D, and of the Angle B C D.

rally made the first Meridian upon the Terrestrial Globe.

But different Nations fix the first Meridian in different Places : Some *English* Geographers and Map-makers, make that to be the first Meridian which passes thro' *London*.

Two of these Semicircles joined together, so as to compleat the Circle, are called *Whole Meridians*. Such a one is expressed by the brazen Circle in which the Globe turns, and by which it is divided into the Eastern and Western Hemispheres. The graduated Edge of this Meridian represents the Meridian of any Place, when, by turning the Globe, the Place is brought just under it.

Meridians at fifteen Degrees distance from each other are called *Hour-Circles*; because the Places that each of them pass through have Noon an Hour earlier than at fifteen Degrees more Westward, and later than at fifteen Degrees more Eastward.

N. B. The Horizon and Meridians are called *changeable Circles*; because by changing our Place, Eastward or Westward, we change our Meridian; since the Meridian of any Place is a Circle passing, North and South, directly over it. And by removing towards any Point of the Compass we change our Horizon, both sensible and Rational;

tional ; since both the Prospect all around us, and the Hemisphere which we stand in the Middle of, are now bounded by different Circles than they were before.

The Changeableness of these Circles is represented by the Globes being made to move within them ; by which Means any Place can be brought under its proper Meridian ; and into the Middle of the Hemisphere which is bounded with its proper Horizon.

IV. The ECLIPTIC cuts the Equator obliquely in two opposite Points, making with it an Angle of twenty-three Degrees and a half. This is that Circle round the Earth, which answers to the Sun's apparent annual Path in the Heavens : Or it is such a Circle on which if you suppose a Man to travel round the World, in the Space of a Year, keeping pace with the Sun's apparent annual Motion, *i. e.* about sixty-seven Miles a Day, and suppose he has the Sun *vertical*, or directly over his Head, the first Day at Noon, he will have the Sun directly over his Head every Day at Noon throughout the Year.

This Circle is divided into twelve times 30 Degrees, in all 360. These twelve Portions of the Ecliptic are called by twelve different Names, *viz.*

I. γ Aries,

Ch. 1. *its Points and Circles.* 7

1. ♈ Aries, *the Ram.* 2. ♉ Taurus, *the Bull.* 3. ♊ Gemini, *the Twins.* 4. ♋ Cancer, *the Crab.* 5. ♌ Leo, *the Lion.* 6. ♍ Virgo, *the Virgin.* 7. ♎ Libra, *the Balance.* 8. ♏ Scorpio, *the Scorpion.* 9. ♐ Sagittarius, *the Archer.* 10. ♑ Capricornus, *the Goat.* 11. ♒ Aquarius, *the Waterer.* 12. ♓ Pisces, *the Fishes.*

These Names refer to the Stars, among which the Sun seems to pass in his annual Circuit round the Earth. These are called the twelve Signs of the Zodiac. If we would know to what Part of the Ecliptic the Sun is vertical any time of the Year, we may learn it from the four innermost Circles upon the wooden Horizon.

On the first, or innermost, are marked the Degrees of the twelve Signs.

The second has the Names, Characters, and Figures of those Signs.

The third is a Kalendar of Months and Days, according to the Old Style, answering to the Degrees of the twelve Signs; by which is seen what Sign and Degree the Sun is in every Day throughout the Year.

The fourth is a Kalendar, in the same manner, according to the New Style.

N. B. Points at 90 Degrees distant from any greater Circle, are called the Poles of that Circle. But when we speak of THE POLES, without mentioning the Circle to which they relate, we always mean

mean the Poles of the Equator, which are the Extremities of the Axis of the Earth's diurnal Rotation. These are also called the Poles of the World.

Suppose the Earth were cut in half at any greater Circle, it would produce a Plane, which is called the Plane of that Circle; as the *Plane of the Equator*; the *Plane of the Meridian*, &c.

A Map representing the Surface of half the Globe, is said to be projected upon the Plane of the Meridian, when the Pole of the Meridian is in its Center; and the Poles of the Equator are in the Periphery or Circumference. A Map projected upon the Plane of the Equator, has the Pole of the World in its Center. A Map projected upon the Plane of the Horizon of *London*, has *London* in the middle of it.

N. B. Maps of the World are generally projected upon the Plane of the Meridian; but Maps of the Stars upon the Plane of the Equator, or of the Ecliptic.

Of the Lesser Circles, viz. the Tropics, the Polar Circles, Parallels of Latitude, and the Horary Circle.

I. The TROPICS are two lesser Circles, each at $23\frac{1}{2}$ Degrees from the Equator, to which they are parallel or equidistant in all Parts. That on the North of the
Equator

Equator is called the *Tropic of Cancer*, to which the Sun is vertical at the Summer Solstice, or longest Day of the Year to the Northern Hemisphere. That on the South is the *Tropic of Capricorn*, to which the Sun is vertical at our Winter Solstice, which is the longest Day of the Year to the Southern Hemisphere.

II. The two POLAR CIRCLES are parallel to the Tropics, each at $23\frac{1}{2}$ Degrees distant from the Pole. The Northern is called the *Arctic Circle*, the Southern the *Antarctic*.

N. B. A Globe which does not consist of one continued Surface, but only of the greater and lesser Circles, made of Brass, Wood, Pastboard, &c. and put together in their natural order, is called an *Armillary Sphere*.

Other Circles drawn parallel to the Equator are called PARALLELS of LATITUDE: 90, or rather 89, such Circles drawn at equal Distances betwixt the Equator and the Pole, mark the Degrees of *Latitude*, which are number'd on the graduated Edge of the Brazen Meridian.

The *Parallels of Latitude* and *Meridians* are the Lines which are drawn upon Maps, crossing one another, and marking the Degrees of *Latitude* and *Longitude*.

III. The Brass Circle with an Index fasten'd at the North Pole of the Globe, is called the **HORARY CIRCLE**; it is divided into twice 12 Hours, answering to the Time in which the Earth performs its diurnal Revolution: The upper 12 is for 12 at Noon, the lower for 12 at Night.



Of the Divisions of the Earth.

THE whole Surface of the terraqueous Globe admits of several different Divisions; as

FIRST, By the various Positions of the Globe in respect to the *Horizon*.

1. Where the Poles of the Horizon are in the Equator, it is called a *Right Sphere*; because then the Equator, and all its Parallels, cut the Horizon at right Angles. There the Poles of the World are in the Horizon; all the Stars rise and set, and the Days and Nights are always equal.

2. Where the Poles of the World are the Poles of the Horizon, it is called a *Parallel Sphere*; the Equator, and all its Parallels,

Ch. 2. *The Divisions of the Earth.* 11

ralls, being then parallel to the Horizon. There the Sun, Moon, and Stars, appear to move round in Circles parallel to the Horizon; the same Hemisphere of fixed Stars is always above the Horizon; and there is but one Day and one Night in a Year, each of six Months.

3. When the Poles of the Horizon are any where betwixt the Equator and the Poles of the World, it is called an *Oblique Sphere*; the Equator, and its Parallels, there crossing the Horizon obliquely. There some Stars never set, others never rise; the Days and Nights are of different Lengths in different Seasons of the Year; and there one Pole of the World only is seen, which is elevated, more or less, according to the Obliquity of the Sphere. For the *Elevation of the Pole*, in any Place, is the Height of it above the Horizon, measured by Degrees on the Meridian; and it is always equal to the Latitude of the Place: So that the Pole being duly elevated for any Place, and the Place brought under the graduated Edge of the brazen Meridian, it is exactly in the Pole of the Horizon.

SECONDLY, The Division of the Earth into *Zones*.

The Tropics and Polar Circles divide the Globe into five *Zones*, or Belts, which have their Names from the different Degrees of

Heat and Cold, which, by their Situation, they are subject to, *viz.* One *Torrid Zone*, two *Temperate*, and two *Frigid*. The *Torrid Zone* lies betwixt the two Tropics; the two *Temperate Zones* are comprehended betwixt the Tropics and Polar Circles; and the two *Frigid Zones* lie within the Polar Circles.

THIRDLY, The Divisions of the Earth by the relative Situation of its Inhabitants to one another, in respect to Days and Seasons.

1. Those who live in the same Degree of Longitude, and in equal Latitudes, one North, the other South of the Equator, are called *Antæci*. The Hour of the Day and Night are the same with both, but the Seasons of the Year are contrary.

2. Those who live in the same Latitude, but in opposite Points of Longitude, are called *Periæci*. Their Length of Days and Seasons of the Year are the same; but their Days and Nights are contrary.

3. Those who live in equal Latitudes, one North, the other South, and also in opposite Points of Longitude, are called *Antipodes*. These have Days, and Nights, and the Seasons of the Year, all contrary to one another.

FOURTHLY,

Ch. 2. *The Divisions of the Earth.* 13

FOURTHLY, The Division of the Earth by *Climates*.

Climates are bounded by Parallels of Latitude, drawn at such a Distance from each other, as that the longest Day at the lesser Parallel, exceeds that at the next greater Parallel, by half an Hour. There are twenty-four such *Climates* betwixt the Equator and each Polar Circle, which grow narrower as they lie farther distant from the Equator. And there are reckoned fix *Climates* more from the Polar Circle to the Pole, which increase not by half Hours, but by Months.

A TABLE of the CLIMATES.

Climates	From the Equator to the Polar Circles				Climates	From the Equator to the Polar Circles			
	Ends in Latitude		Where the longest Day is			Ends in Latitude		Where the longest Day is	
	D	M	H	M		D	M	H	M
1	8	25	12	30	17	64	06	20	30
2	16	25	13	00	18	64	49	21	00
3	23	50	13	30	19	65	21	21	30
4	30	20	14	00	20	65	47	22	00
5	36	28	14	30	21	66	06	22	30
6	41	22	15	00	22	66	20	23	00
7	45	29	15	30	23	66	28	23	30
8	49	01	16	00	24	66	31	24	00
9	51	58	16	30	From the Polar Circles to the Poles				
10	54	27	17	00	1	67	30	1	Months
11	56	37	17	30	2	69	30	2	
12	58	29	18	00	3	73	20	3	
13	59	58	18	30	4	78	20	4	
14	61	18	19	00	5	84	00	5	
15	62	25	19	30	6	90	00	6	
16	63	22	20	00					

FIFTHLY,

FIFTHLY, The natural and political Divisions of the Earth.

By the *natural Division* we mean that which Nature has made in the Surface of the Globe, as *Land* and *Water*. The Land is again divided into *Continents, Islands, Peninsulas, Isthmus's, Promontories, Coasts, &c.* The Water is also distinguished into *Seas, Oceans, Lakes, Gulphs, Bays, Straits, Rivers, &c.*

The *political Division* of the Earth is made by Men, who have distinguished it into *four Quarters*; and these again into *Empires, Kingdoms, States, Republics, Principalities, Provinces, Counties, Parishes, &c.* For a particular Description of all which we refer to *Gordon's Geographical Grammar*, or some larger System of Geography.



C H A P. III.

A Description of the Celestial Globe, its Points and Circles.

THE Celestial Globe is an artificial Representation of the Heavens, having the fixed Stars drawn upon it, in their natural Order and Situation.

It is not pretended that the Celestial Globe is so just a Representation of the
Heavens,

Heavens, as the Terrestrial Globe is of the Earth; because *here* the Stars are drawn upon a convex Surface, whereas they naturally appear in a concave one. But suppose the Globe were made of Glass, then to an Eye placed in the Center, the Stars which are drawn upon it would appear in a concave Surface, just as they do in the natural Heavens.

As the Terrestrial Globe, by turning on its Axis, represents the real diurnal Motion of the Earth; so the Celestial Globe, by turning on its Axis, represents the apparent diurnal Motion of the Heavens.

The Circles and Points which are either peculiar to the Celestial Globe, or which have not been taken notice of in explaining the Terrestrial, are these that follow:

1. The *Zodiac*, which is a Hoop, or Belt round the Heavens, of about sixteen Degrees broad; along the middle of it runs the *Ecliptic*, or the Sun's annual Path. The *Signs of the Zodiac* are the fixed Stars that are contained in this celestial Belt; and which, for distinction sake, are thrown into twelve *Constellations*, or *Asterisms*, and are called *Aries*, *Taurus*, &c.

2. The two *Colures*, which are whole Meridians, one passing thro' the first Point of *Aries* and *Libra*, where the *Ecliptic* crosses the *Equinoctial*, (the Circle that answers to the Equator on the Terrestrial Globe.)

Globe.) The other passing thro' the first Points of Cancer and Capricorn, where the *Ecliptic* touches the *Tropics*. The former is called the *Equinoctial Colure*, the latter the *Solstitial Colure*.

3. The first Points of Aries and Libra are called the *Equinoctial Points* *; because, when the Sun is in either of them, the Day and Night is every where equal.

4. The first Points of Cancer and Capricorn are called the *Solstitial Points* †; because when the Sun arrives at either of them, he seems to stand in a manner still, in respect to his apparent motion from and towards the Equinoctial, for several Days. When he is in one Solstitial Point, he makes the longest Day; when in the other, the shortest, to one and the same Northern, or Southern Hemisphere.

5. The Point in the Heavens just over our Head is called the *Zenith*; and the opposite Point to it, just under our Feet, is called the *Nadir*. These two are the Poles of the Horizon.

Imaginary Circles, drawn thro' the *Zenith* and *Nadir*, and cutting the Horizon at right Angles, are called *Vertical*, or *Azimuth Circles*. Hence the Distance of the Sun, or a Star, from the Meridian, or

* *Equinoctial*, from *æquus* equal, and *Nox* Night.

† *Solstitial*, from *Solis statio*, the Sun's Station, or standing Place.

South Point of the Heavens, measured by Degrees upon the Horizon, is called its *Azimuth*; or sometimes the Azimuth is reckoned from any other of the cardinal Points.

The Azimuth of the Sun, or a Star, from due East or West, at the Time of its Rising or Setting, is called its *Amplitude*.

6. The Brass *Quadrant of Altitude*, screw'd upon the Zenith, and laid down to the Horizon, represents a Quarter of a vertical Circle. It is called the *Quadrant of Altitude*, from its Use in taking the Altitude, or Height, of the Sun or Stars, above the Horizon, by means of the 90 Degrees marked upon it. The Sun's Height at Noon above the Horizon is called his *Meridian Altitude*; and when he reaches that Height, he is said to *Culminate*.

The Distance of the Sun, or a Star, from the Horizon, below it, is called its *Depression*.

Imaginary Circles drawn parallel to the Horizon, thro' every Degree of the vertical Circles, are called *Parallels of Altitude*, or, (by an Arabick Name) *Almicantars*.

7. *The Poles of the Ecliptic* are generally marked on the Celestial Globe, which fall in the Arctic and Antarctic Circles, at $23\frac{1}{2}$ Degrees distant from the Poles of the Equinoctial.

8. Great Circles cutting the Ecliptic at right Angles, and crossing one another at its Poles, are called *Circles of Longitude*. And if you imagine other Circles to be drawn parallel to the Ecliptic, thro' every Degree of the Circles of Longitude, they will be *Parallels of Latitude* upon the Celestial Globe. For *Longitude* and *Latitude* on the Celestial Globe, bear just the same relation to the Ecliptic, as they do on the Terrestrial Globe to the Equator.

Thus, as the Longitude of Places on the Earth is measured by Degrees upon the Equator, counting from the first Meridian; so the Longitude of the heavenly Bodies is measured by Degrees upon the Ecliptic, counting from the first Circle, or Line of Longitude, viz. that which passes thro' the first Point of Aries. And as Latitude on the Earth is measured by Degrees upon the Meridian, counting from the Equator; so the Latitude of the heavenly Bodies is measured by Degrees upon a Circle of Longitude, counting either North, or South, from the Ecliptic.

The Sun has no Latitude, being always in the Ecliptic: nor do we usually speak of his Longitude; but his Place in the Ecliptic is expressed by such a Degree and Minute, of such a Sign; as 5 Degrees of Taurus, instead of 35 Degrees of Longitude.

9. The Distance of any heavenly Body from the Equinoctial, measured upon the Meridian, is called its *Declination*. Therefore the Sun's Declination, North or South, at any Time, is the same as the Latitude of the Place on Earth, to which he is then vertical; which is never more than $23\frac{1}{2}$ Degrees. Therefore, also, *Parallels of Declination* on the Celestial Globe, are the very same as *Parallels of Latitude* on the Terrestrial.

Stars may have *North Latitude*, and *South Declination*, and vice versa.

The same Thing which is called Longitude on the Terrestrial Globe, is called *right Ascension* on the Celestial; viz. the Sun, or a Star's Distance from the first Meridian, or that which passes thro' the first Point of Aries, counted on the Equinoctial.

Astronomers also speak of *oblique Ascension* and *Descension*; by which they mean the Distance of that Point of the Equinoctial from the first Point of Aries, which, in an oblique Sphere, rises, or sets, at the same time that the Sun, or Star, rises, or sets.

Ascensional Difference, is the Difference betwixt right and oblique Ascension. The Sun's ascensional Difference, turned into Time, (*i. e.* reckoning one Degree to be four Minutes, and fifteen Degrees one Hour)

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is just so much as he rises before, or after,
fix a Clock.

The Hemisphere of Stars, which is visible by Night, is continually changing, in a right or oblique Sphere, by reason of the Sun's apparent Motion round the Ecliptic in a Year.

When the Sun gets so near a Star, as that the Star is hid in his Beams, it is said to set *Heliacally*: and when, after its Conjunction with the Sun, it becomes visible again, it is said to rise *Heliacally*.

A Star that rises, or sets, in the Morning, when the Sun rises, is said to rise, or set, *Cosmically*.

A Star which rises, or sets, in the Evening, when the Sun sets, is said to rise, or set, *Achronically*.



*Of the Divisions of the Heavens,
and the Constellations.*

THE Stars appearing to be of different Sizes, some greater, and some less, Astronomers have divided them into six *Classes, or Magnitudes*; and the Stars of each

each Magnitude are distinguished by different Marks on the Celestial Globe.

They have also distinguished the Stars, in respect to their Situation in the Heavens, into several *Constellations*, or *Asterisms*, to which they have given Names: to some the Names of Men; to others the Name of Beasts, Birds, and several other Things, as fancy led them. The Images of those Animals, and other Things, from whence the Names of the Constellations are taken, are drawn upon the Celestial Globe, over the several Parcels of Stars which are called by those respective Names*.

The Constellations are divided into *Northern* and *Southern*; besides the twelve *Zodiacal Signs*, which lie in the Middle betwixt both.

In the Northern Regions the Ancients formed twenty-one Constellations, *viz.* *Ursa Minor*, or the little Bear; *Ursa Major*, the great Bear; *Draco*, the Dragon; *Cepheus*; *Cassiopeia*; *Andromeda*; *Triangulum*, the Triangle; *Perseus*, with *Medusa's* Head; *Auriga*; *Bootes*; *Corona Septentrionalis*, the Northern Crown; *Hercules*; *Lyra*, the Harp; *Cygnus*, the Swan; *Pegasus*, the flying Horse; *Equiculus*, the little Horse's

* N. B. The Letters of the *Greek* and *Latin* Alphabets, which are placed by many of the Stars on *Senex's* Celestial Globe, are those by which *Bayer* has marked them in his Catalogue of the Stars.

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Head; *Delphinus*, the Dolphin; *Sagitta*, the Arrow; *Aquila*, the Eagle or Vultur; *Serpens*, the Serpent; and *Serpentarius*, the Man who holds it.

To these the Moderns have added several more, as *Antinous*, near the Eagle; *Coma Berenices*, or Berenice's Hair, near the Lion's Tail; *Leo minor*, the little Lion, betwixt the Lion and the great Bear, &c.

South of the Zodiac the Antients numbered fifteen Constellations, *viz.* *Cetus*, the Whale; the River *Eridanus*; *Lepus* the Hare; *Orion*, which is the most glorious Constellation of all; *Canis major*, the great Dog; *Canicula*, the little Dog; *Argo Navis*, the Ship Argo; *Hydra*; *Crater*, the Cup; *Corvus*, the Crow; *Centaurus*, the Centaur; *Lupus*, the Wolf; *Corona Australis*, the Southern Crown; *Ara*, the Altar; and *Piscis Australis*, the Southern Fish.

To these the Moderns have added twelve Constellations more, which lie so near the South Pole, that they cannot be seen in our Northern Latitude.

There are still some Stars scattered about the Heavens, out of any of the Constellations, which are called *Unformed Stars*.

Some remarkable Parcels of Stars, in some of the Constellations, have also obtained Names by themselves; as the *Pleiades*, or Seven Stars, in the Constellation *Taurus*;

Taurus; *Charles's Wain*, which are seven bright Stars in the hinder Part of the *great Bear*: the three in his Tail are supposed to represent the three Horses, and the other four the Wain. The two hindermost Stars in the Wain are also called the *Pointers*, because they point to the Pole Star, which is in the Tip of the Tail of the little Bear; that is, a Line drawn thro' these two Stars, and protracted as far as the Pole, will nearly touch the Pole Star.

Many single Stars also, especially of the first and second Magnitude, have particular Names given them; as *Sirius*, in the great Dog; *Aldebaran*, or the Bull's Eye; *Procyon*, in the little Dog; *Arcturus* in Bootes; *Regel*, in Orion; the *Lion's Heart*; and *Deneb*, in his Tail; *Spica Virginis*, or the Ear of Corn in the Virgin's Hand; *Castor* and *Pollux*, in the Constellation Gemini; and several others.

The *Galaxy*, or Milky Way, is a broad, irregular, whitish Circle, in some Places double, but for the most part single, surrounding the whole Heavens. Modern Astronomers have discovered, by their Telescopes, that there is an innumerable Multitude of Stars in those Parts of the Heavens, which are too small to be distinguished by the naked Eye, whose united Rays occasion the shining Whiteness of that Circle. And to the same Cause they ascribe
some

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some other bright Spots in the Heavens, as particularly the *Præsepe*, or Asses and Manger, in the Constellation *Cancer*.

As for the Connection betwixt the several Parcels of Stars, which form the Constellations, and the Figures after which they are named, it can hardly be discovered in the Constellations themselves; except perhaps in a very few of them, as *Charles's Wain* may be supposed a little to represent a Wain or Waggon with three Horses; but a very strong Imagination would find it extremely difficult to discover any such natural Resemblance, betwixt the Bulk of the Constellations, and the Figures they are named by. The Author of *Spectacle de la Nature*, Vol. I. has an ingenious Conjecture on this Head, *viz.* He conceives it highly probable that the Zodiacal Constellations were first formed and named by the *Egyptians*, who dealt much in Hieroglyphics, or mystic Figures; by which they expressed, in a covert Manner, the Doctrines and Secrets of their Religion, Philosophy and Politicks. Thus a *Lion* was the Hieroglyphic of Strength and Fortitude, a *Horse* of Liberty, a *Circle* of Eternity, &c. Now this Author imagines the twelve Signs of the Zodiac were such *Egyptian* Hieroglyphics, by which they designed to express or represent some remarkable natural Occurrence in each Month

Month of the Year, as the Sun was passing thro' the respective Constellations.

The first three Months, beginning from the vernal Equinox, were remarkable for the Production of those Animals which they most used and valued, *viz.* *Sheep*, *Kine* and *Goats*. The *Lambs* come first, which are represented by their Parent the *Ram*; next the *Calves*, represented by the *Bull*; and then the *Kids*, which commonly come in Pairs, and which therefore gave the Name to the third Constellation. But instead of the *Twin Kids*, the *Greeks* have since substituted the *Twin Brothers Castor* and *Pollux*.

When, in the fourth Month, the Sun is arrived at the Summer Solstice, he discontinues his Progress towards the North Pole, and begins to go back again to the Southward; which retrograde Motion the *Egyptians* expressed by the *Crab*, which is said to go backward.

The excessive Heat that usually follows in the next Month is signified by the *Lion*, an Animal remarkable for his Strength and Fierceness.

Nothing could be more proper than the Symbol for the Harvest Month, *viz.* the *Virgin Reaper* or *Gleaner* with an Ear of Corn in her Hand. Our Author here Remarks by the Way that the *Arabic* Name for the Ear of Corn, *viz.* *Sibbula* or *Sibbul*, was probably given to the Virgin who car-

ried it, and might give Rise to the Fable of the *Erythræan Sibyl*, who was inspired to foretel Years of Plenty or Scarcity; and from whom some other Women, who pretended to the Gift of Prophecy, were likewise called *Sibyls*, as the *Delphic Sibyl*, the *Cumæan Sibyl*, &c.

The seventh Constellation, when the Sun arrives at the Autumnal Equinox, is expressed by the *Ballance*, or *Pair of Scales in Equilibrio*, because Days and Nights are then every where equal.

October is often a sickly Season, when the Surfeits got in the hot Months of the Summer produce their fatal Effects; the Symbol is therefore the *Scorpion*, who wounds with a Sting in his Tail, as he is going away.

The Diversion of Hunting, which is chiefly followed after the Fall of the Leaf, is signified by the *Sagitary* or *Archer*; which the *Greeks* have probably changed into the fabulous *Centaur*.

As the *Crab*, which goes backward, signified the Summer Solstice, when the Sun begins to go back from the Northern Tropic, so the *Goat*, which delights to browse up Hill, is the Symbol of the Winter Solstice, when the Sun begins to ascend from the Southern Tropic, and is continually mounting higher and higher for the ensuing half Year.

Aquarius,

Aquarius, or the *Water Pot*, fitly represents the Rains and Snows of the Winter. And,

The two Fishes in a Band, had probably a Reference to the prime fishing Season, which begins in *February*.

As for the rest of the Constellations, which are out of the Zodiac, the Bulk of them were formed by the *Grecians*, who imitated the *Egyptians* in giving the Names of Men and Animals to Parcels of Stars; but without any such particular Reasons as the *Egyptians* had for naming the twelve Signs of the Zodiac.

This is the Substance of what that Author says upon this Subject. How far he has hit on the Truth of the Case, cannot now be determined; however,

This I dare boldly tell,
'Tis so like Truth, 'twill serve our Turn as well.
COWLEY.



C H A P. V.

The Use of the Globes.

PROBLEM I. To find the *Latitude* and *Longitude* of any given Place on the Terrestrial Globe.

Bring the Place to the graduated Edge of the brazen Meridian; then the Degree
E 2
marked

marked on the Meridian over it shews its Latitude; and the Degree of the Equator, then under the Meridian, shews its Longitude. Hence, if the Latitude and Longitude of any Place be given, the Place is easily found, by bringing the given Longitude to the Meridian, for then the Place will lie under the given Degree of Latitude upon the Meridian.

PROB. II. To find the Distance of any two Places on the Terrestrial Globe.

Lay the Quadrant of Altitude on both Places; or take the Distance between them with a Pair of Compasses, and apply it to the Equator. The Number of Degrees on the Quadrant between them, or betwixt the Feet of the Compasses on the Equator, reduced to Miles, (that is, 70 to a Degree) shews their Distance in Miles. In the same manner the Distance of any two Stars may be found on the Celestial Globe, in Degrees, tho' not in Miles.

PROB. III. To find the *Antæci*, *Periæci*, and *Antipodes*, of any given Place.

Bring the given Place to the Meridian, and observe its Latitude. The same Latitude, counted towards the contrary Pole, and under the same Meridian, shews the Place

Place of the *Antæci*. Keep the given Place under the Meridian, set the Hour-Index to 12 at Noon, then turn the Globe till the Index points to 12 at Night, and the Place that is now under the same Degree of the Meridian, that the first given Place was, is that of the *Periæci*. The *Antipodes* of the first Place, are now under the same Degree of the Meridian that the *Antæci* were before.

PROB. IV. To rectify the Globe for the *Latitude, Zenith, and Sun's Place.*

1. For the *Latitude*; Elevate the Pole above the Horizon, according to the Latitude of the Place.

2. For the *Zenith*; Screw the Quadrant of Altitude on the Meridian, at the given Degree of Latitude, counting from the Equator towards the elevated Pole.

3. For the *Sun's Place*; Bring the Sun's Place in the Ecliptic (found in the Kalendar on the wooden Horizon, against the Day of the Month) to the Meridian, and set the Hour-Index to 12 at Noon.

PROB. V. The Hour being given at any Place, to find what Hour it is in any other Part of the World.

Bring

Bring the the given Place to the Meridian, and set the Hour-Index to the given Hour; then, by turning the Globe, bring any Place to the Meridian, and the Index will point to the Hour at that Place.

PROB. VI. The Day and Hour at any Place being given, to find where the Sun is in the *Zenith* at that Hour.

Bring the Sun's Place to the Meridian, and note the Degree over it (which is the Sun's Declination at that time;) then bring the given Place to the Meridian, and set the Index to the given Hour; turn the Globe till the Index points to 12 at Noon, and the Place on the Globe, which lies under that Degree of the Meridian that was before noted, has the Sun just then in its *Zenith*.

PROB. VII. The Day and Hour being given, to find all those Places of the Earth where the Sun is *Rising*, *Setting*, or *Calminating*; and also where it is *Day-light*, *Twilight*, or *Dark-night*.

Find the Place where the Sun is vertical at the given Hour (by PROB. VI.) rectify for the Latitude of that Place, and bring it to the Meridian. Then all the Places that

that are in the West Semicircle of the Horizon, have the Sun *rising*; those in the East Semicircle have it *setting*; those under the Meridian, above the Horizon, have it *culminating*; and all Places above the Horizon, have the Sun so many Degrees above the Horizon as the Places themselves are. Those Places that are below the Horizon, but within 18 Degrees of it, have *Twilight*; and those lower than 18 Degrees have *Dark-night*.

PROB. VIII. Any Place, whose Latitude is less than $66\frac{1}{2}$ Degrees, being given, and the Day of the Month; to find at what Hour the Sun rises and sets, and the Length of Day and Night.

Rectify for the Latitude and Sun's Place; then bring the Sun's Place to the East or West Part of the Horizon, and the Index will point to the Hour of the Sun's rising, or setting; and the Hour of his rising, or setting, doubled, gives the Length of the Night, or Day.

PROB. IX. Any Place, whose Latitude is more than $66\frac{1}{2}$ Degrees North, being given, to find the Time when the Sun begins to appear above the Horizon, and when it begins to disappear; and

and also the Length of the longest Day or Night in that Place.

Rectify for the Latitude, bring the ascending Part of the Ecliptic * to the South Point of the Horizon, observe the Degree of the Ecliptic which cuts that Point, and see in the Kalendar what Day the Sun enters into that Degree, for that is the Day when the Sun begins to appear in that Latitude. In like manner bring the descending Part of the Ecliptic to the same Point of the Horizon, and the Kalendar will shew, as before, when the Sun leaves that Latitude, and entirely disappears. Again, bring the ascending Part of the Ecliptic to the North Point of the Horizon, note the Degree, as before, and the Kalendar will shew when the longest Day begins; bring the descending Part of the Ecliptic to the said North Point, and you will find, by the same Method, when the longest Day ends. *N. B.* The longest Night is every where equal to the longest

* *N. B.* The ascending Part of the Ecliptic is that in which, while the Sun proceeds in his annual Course, he is daily ascending, or rising higher and higher every Day at Noon. The descending Part is that in which he is daily descending, or falling lower and lower. Thus, in all Latitudes that lie North of the Tropic of Cancer, the ascending Part is the Semicircle from Capricorn to Cancer; but in Latitudes South of the Tropic of Capricorn, it is the Semicircle from Cancer to Capricorn.

Day.

Day. Thus, at the North Cape of *Lapland*, 71 Degrees Latitude, the Sun begins to appear above their Horizon, when he arrives at about 6 Degrees of *Aquarius*, that is, on the 14th or 15th of *January*. Their longest Day begins near the Beginning of *May*, and the Sun continues above their Horizon, without setting any more, till after the Middle of *July*. And he goes entirely below their Horizon, and their longest Night begins, near the Beginning of *November*. So that their longest Day, and longest Night, are each of them upwards of two Months.

PROB. X. The Latitude of any Place being given, and the Day of the Month, to find the *Beginning*, and *End*, and *Duration* of *Twilight*, and of *Dark-night*.

Rectify for the Latitude, Zenith, and Sun's Place; bring the Point which is opposite to the Sun's Place, by turning the Globe Westward, or Eastward, to cut 18 Degrees of the Quadrant of Altitude; then will the Index shew when Twilight begins, or ends. And the Time when Twilight begins, taken from the Time of the Sun's Rising, leaves the Duration of Twilight. And the Time when Twilight begins, doubled, gives the Length of Dark-night.

F

PROB.

PROB. XI. The Latitude, Day of the Month, and Hour being given to represent the Face of the Heavens, at that time, on the Celestial Globe.

Rectify for the Latitude, and Sun's Place; set the Globe on an Horizontal Plane, with its cardinal Points directed to the corresponding cardinal Points in the Heavens; turn the Globe till the Index points to the given Hour: then does the Surface of the Globe represent the Face of the Heavens, in relation to the Horizon of the given Place, at that Hour; exactly, if it be 12 at Noon, and pretty nearly if it be any other Hour.

PROB. XII. To find the *Latitude* and *Longitude* of any given *Star*.

Put the Center of the Quadrant of Altitude on the Pole of the Ecliptic, and its graduated Edge on the given Star; then the Arch of the Quadrant, intercepted betwixt the Star and the Ecliptic, shews its Latitude; and the Degree which the Edge of the Quadrant cuts on the Ecliptic, is the Degree of its Longitude.

PROB. XIII. To find the *Declination* and *Right-Ascension* of the *Sun*, or any *Star*.

Bring

Bring the Sun's Place, or the Star, to the Meridian; then the Degree of the Meridian over it shews its Declination; and the Degree of the Equinoctial at the Meridian, shews its Right-Ascension.

PROB. XIV. The Place and Day being given to find the *Sun or Star's eastern or western Amplitude, oblique Ascension and Descension, ascensional Difference, and semidiurnal Arch.*

Rectify for the Latitude and Sun's Place; bring the Sun's Place, or the Star, to the east or west Part of the Horizon; then the Arch betwixt it and the east or west Point of the Horizon, shews its eastern, or western *Amplitude*. The Degree of the Equinoctial, where it cuts the Horizon, shews the *oblique Ascension, or Descension*; and the Difference betwixt the right and oblique Ascension (or if it be of the Sun, the Difference betwixt the Hour which the Index points to, and Six) is the *ascensional Difference*; which being converted into Time, and added to Six, when the Sun, or Star, declines towards the elevated Pole, (*i. e.* in Northern Latitude, when it has North Declination) or subtracted from Six, when it declines towards the depressed Pole, gives half the Time of its Stay above the Horizon; which, when we speak of

the Sun, is called the *semidiurnal Arch*. The Compliment of the semidiurnal Arch to Twelve, gives the *seminocturnal Arch*, or half the Time of its Stay below the Horizon. The Sun's semidiurnal Arch, computed from Noon, gives the Time of his Setting; and his seminocturnal Arch, computed from Midnight, gives the Time of his Rising.

PROB. XV. The Latitude and Sun's Place being known, then, if either the *Hour of the Day, or Night*, or the *Altitude*, or *Azimuth*, of the *Sun*, or *Star*, be given, to find the other two.

Rectify for the Latitude, Zenith, and Sun's Place; then

1. If the *Hour* be given, turn the Globe till the Index points to it, and bring the Quadrant of Altitude down to the Sun or Star's Place; so will the graduated Edge shew the Degree of Altitude; and the Degree of the Horizon, where the Quadrant cuts it, shews the Azimuth.

2. If the *Altitude* be given, bring the Sun or Star's Place to meet with the Quadrant at the given Altitude; then the Index will point to the Hour, and the Intersection of the Quadrant and Horizon will shew the Azimuth.

3. If

3. If the *Azimuth* be given, bring down the *Quadrant* to intersect the *Horizon* at the given *Azimuth*; then, by turning the *Globe*, bring the *Sun's Place* or *Star*, to meet with the *Quadrant*, and the *Degree* on the *Quadrant* where they meet, shews the *Altitude*, and the *Index* points to the *Hour*.

Hence, if the *Altitude* and *Azimuth* of any *Star* in the *Heavens* be taken by *Observation* with proper *Instruments*, it is easy to find that *Star* on the *Globe*; and, by taking the *Altitude* and *Azimuth* of any *Star* upon the *Globe* at a given *Hour*, the same *Star* may be found in the *Heavens*.

PROB. XVI. The *Latitude* of a *Place* being given; to find the *Cosmical*, *Achronical*, and *Heliacal* rising or setting of any given *Star*,

Rectify for the *Latitude*; then

1. Bring the *Star* to the east or west Part of the *Horizon*, observe the *Degree* of the *Ecliptic* then rising; over-against this *Degree* in the *Kalendar* is found the *Day* of the *Star's Cosmical* rising or setting. Thus *Lat.* $51\frac{1}{2}$ N. *Sirius* rises cosmically *July* 31, sets cosmically *November* 5.

2. Bring the *Star* to the east or west Part of the *Horizon*, observe the *Degree* of the *Ecliptic* then setting; and over-against

against it in the Kalendar is found the Day or the Star's *Achronical* rising or setting. Thus *Sirius* rises achronically *January 26*, sets *May 3*.

3. Rectify for the Zenith, bring the Star to the east Part of the Horizon, and bring down the Quadrant of Altitude on the western Side, to cut the Ecliptic at that Degree of the Quadrant, which is the Star's Arch of Vision, (which, if it be a Star of the first Magnitude, is the 12th Degree from the Horizon;) observe the Degree of the Ecliptic, which is thus cut by the Quadrant, (which, when the Star rises, is twelve Degrees high above the western Horizon; and, consequently, the opposite Point to this in the Ecliptic is twelve Degrees below the eastern Horizon,) look the opposite Point in the Kalendar, and you have the Day of that Star's rising heliacally. Again, bring the Star to the west Part of the Horizon, and the Quadrant to the east Side, till the 12th Degree of it cuts the Ecliptic; look for the opposite Point of the Ecliptic to that which is thus cut by the Quadrant, and find when the Sun comes to that Point which gives the Time of the Star's heliacal setting. Thus *Sirius* rises heliacally *August 15*, sets *April 16* *.

PROB.

* From the heliacal rising of *Sirius*, the Ancients reckoned their *Dies Caniculares*, or *Dog-Days*, to 30,

PROB. XVII. The Day of the Month being given; to find when any Star will come to the Meridian.

Rectify for the Sun's Place, turn the Globe till the given Star comes to the Meridian; then the Index will point to the Time sought.

PROB. XVIII. To find when a given Star will come to the Meridian; at any given Hour of the Night.

Bring the given Star to the Meridian, set the Index to 12 at Noon; then turn the Globe eastward, till the Index points to an Hour as far distant in the Forenoon from 12, as the given Hour is in the Afternoon:

40, or 50 Days after it, for they were not all agreed how long the Dog-Days lasted. However, it was the common received Opinion, that the sultry Weather at that Season of the Year was owing to this Star. The Romans in particular, were so persuaded of its malignant Influence, that they are said to have sacrificed a brown Dog annually on the Day of its rising, to appease its Rage. But that this was all a groundless Conceit is very evident; for though in their Time *Sirius* rose about the 17th or 18th of *July*, when the Weather is commonly hottest, yet now he does not rise till the Middle of *August*, when, in most Years, the hottest Season is over. And if the World should continue five or six Thousand Years more, he will not rise until *November* or *December*, when he may happen to be charged with bringing Frost and Snow, instead of Heat. However, our Almanack-makers still continue to mark the Beginning of the *Dog-Days* about the 18th of *July*, and their End about the 28th of *August*.

altered in 1779

Observe

Observe the Degree of the Ecliptic then at the Meridian, over-against which Degree, in the Kalendar, is the Day of the Month when the given Star will be upon the Meridian, at the given Hour.

PROB. XIX. The Latitude of the Place being given; to find the *Hour of the Day* by the Globe when the Sun shines.

Set the Globe on an horizontal Plane, with the Meridian due North and South.

1. In the Summer half Year, elevate the Pole above the North Part of the Horizon, according to the given Latitude.

2. In the Winter half Year, depress the same Pole as much below the South Part of the Horizon; then the Shade of the Axis upon the Hour-circle will shew the Hour of the Day.

PROB. XX. By Observation of a Star upon the Meridian, to find the *Hour of the Night*.

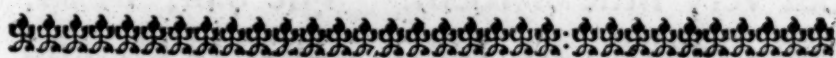
Rectify for the Latitude and the Sun's Place; bring the given Star to the Meridian, and the Index will shew the Hour of the Night.

PART



PART II.

*The Solar System, and the Use of
the Orrery.*



CHAPTER I.

A general View of the Universe.



THE heavenly Bodies, which are visible from the Earth, are *Sun, Moon, and Stars.*

The Stars are of two Sorts.

One Sort (of which there is by far the greater Number) are called *fixed Stars*; because they always appear in the same Places, or at the same Distance, from one another. The other Sort of Stars are called *Planets*, or wandering Stars; because they are perpetually changing their Places and Distances, both with regard to the fixed Stars, and one another.

G

The

The Planets may easily be distinguished from the fixed Stars, by their not twinkling, as the fixed Stars do, excepting those of them which are vertical, or nearly so. And generally the Planets are the Stars which appear soonest in the Evening, and are latest e'er they disappear in the Morning; therefore it is one of the Planets that is the Morning or Evening Star.

The fixed Stars are at such immeasurable Distances from the Earth, that we know but very little of them. The *Sun*, *Moon*, and *Planets*, are much nearer to us, and are better known.

The Sun is a great burning Globe, or fiery Ball, whose Diameter is computed to be 763,000 Miles. It always remains immovable in the vast Expanse, except that it is observed to turn round its own Axis in about twenty-five Days and a half.

Many dark Spots, of various irregular Figures, may commonly be seen, with Telescopes, in the Surface of the Sun; by means of which his Rotation on his Axis has been discovered, and the Time of it ascertained. These Spots are not very permanent, but some of them disappear again in a few Days after their first Appearance. Others of them have been observed to continue during four or five Rotations of the Sun's Body.

The

The Planets are round opaque Bodies, which have no Light of their own, but reflect the Light of the Sun.

The Planets and the Earth (which is truly a Planet) are continually moving round the Sun in Circles, or rather in Ellipses, or Ovals, of different Bignesses, in the following Order.

1. ☿ Mercury is nearest the Sun, and performs his Revolution in about three Months. Fig. II.

N. B. This Planet is always so near the Sun that it is seldom seen.

2. ♀ Venus is next, and revolves in about seven Months and a half.

3. ⊕ The Earth in a Year.

4. ♂ Mars in about two Years.

5. ♃ Jupiter in about twelve Years.

6. ♄ Saturn in about thirty Years.

The Space of Time in which each Planet revolves round the Sun, is also called that Planet's Year. Thus Saturn's Year is equal to about thirty of ours.

These Six are the primary Planets. Some of them have secondary Planets, or Satellites, or Moons, moving continually round them. As the *Moon* round the Earth. Jupiter has four Moons, Saturn has five.

The Planets are of different Magnitudes; some are bigger than the Earth, others are less. Mercury is seven times less than the

Earth; Venus nearly equal to the Earth; Mars six times less; Jupiter one thousand seven hundred and twenty-eight times bigger; Saturn six hundred times bigger; the Moon is sixty times less than the Earth*.

A Machine which represents the Motions of the Planets, is called an ORRERY. And it will very well answer the purpose, if it represents only the Motions of two primary Planets, for Instance, the *Earth* and *Venus*; and of one secondary Planet, viz. the *Moon*: for as the others move in the same Manner, a sufficient Notion may be formed by these, of the Motions of all the rest.

The

* The System of the World here described, is called the *Pythagorean* or *Copernican* System; as having been anciently taught by the wise *Samian* Philosopher *Pythagoras*, and revived, after it had been in a manner lost, by the famous *Polish* Philosopher, *Nicholas Copernicus*, who was born at *Thorn*, in the Year 1473.

The most famous of the antiquated, and now justly exploded Systems, are the *Ptolomean* and the *Tychonian*.

The *PTOLOMEAN* System was taught by *Ptolomy*, an *Egyptian* Astronomer, who is said to have lived 138 Years before Christ. He supposed the Earth to be immovably fixed in the Center of the Universe, and the seven Planets, viz. the *Moon*, *Mercury*, *Venus*, the *Sun*, *Mars*, *Jupiter*, and *Saturn*; and, above them all, the Firmament of fixed Stars, to be constantly revolving round the Earth in twenty-four Hours from East to West.

The *TYCHONIAN* System was taught by *Tycho Brahe*, a noble *Dane*, who was born A. D. 1546. It supposes the Earth to be fixed and immovable, as the *Ptolomean* System does; and that all the Stars and Planets revolve round the Earth in twenty-four Hours: but it differs from the *Ptolomean* in that it not only allows a menstrual Motion

The proportionable Magnitudes, and respective Distances of these Bodies to one another, are not to be conveniently expressed in an Orrery. For suppose a Ball of one Inch Diameter to represent the Earth, then the Ball that represents the Sun should, in true Proportion, be very near eight Feet Diameter, (the Sun being 885,736 times bigger than the Earth) and the Distance of the Earth from the Sun should be about 284 Yards, which is more than half a Quarter of a Mile.

tion to the Moon round the Earth, as the Center of its Orbit, but it makes the Sun to be the Center of the Orbits of *Mercury*, *Venus*, *Mars*, *Jupiter*, and *Saturn*, in which they are carried round the Sun in their respective Years, as the Sun is round the Earth in a Solar Year: and all these Planets, together with the Sun, are supposed to be whirled round the Earth in twenty-four Hours.

This Hypothesis is so embarrassed and perplexed, that but few Persons embraced it. It was afterwards refined upon by *Longomontanus*, and some others; who allowed the diurnal Motion of the Earth on its own Axis, but denied its annual Motion round the Sun. This Hypothesis, partly true and partly false, is called the *Semi-Tychonian* System. However, the *Pythagorean* System has generally been received by the greatest Mathematicians and Philosophers, ever since the Revival of it by *Copernicus*: and it has at length been established on such a solid Foundation of mathematical and physical Demonstration, by the great Sir *Isaac Newton*, as puts it out of all Danger of being ever overthrown by any new contrived System, so long as the Sun and Moon shall endure.



Of the Earth, and its Motions.

THE natural Earth is nearly a Globe, or round Ball whose Diameter is 7,940 Miles *. Its mean Distance from the Sun is 81,000,000 Miles.

Note, The Earth being further off from the Sun at one Time of the Year than another (as will be shewn afterwards) by the *mean Distance* is meant the Medium betwixt the two Extremes; or a Line drawn from the Earth to the Sun, which exceeds the shorter Distance, as much as it falls short of the longer.

The Axis of the Earth is inclined to the Plane of the Ecliptic, making with it an Angle of $66\frac{1}{2}$ Degrees, or with a Perpendicular to the Plane of the Ecliptic an Angle of $23\frac{1}{2}$ Degrees.

* The Unevenness of the Surface of the Earth, as consisting of Mountains and Valleys, is no material Objection against its being considered as round; since the highest Mountains do not bear near so great a Proportion to the Bulk of the Earth, as the little Rifings in the Coat of an Orange bear to the Bigness of that Fruit.

Note,

Ch. 2. *Of the Earth, and its Motions.* 47

Note, The Plane of the Ecliptic is an imaginary Plane, passing thro' the Center of the Sun, and of the Earth.

The Earth has a double Motion. *First*, its diurnal Motion, round its own Axis, in twenty-four Hours. *Secondly*, its annual Motion round the Sun in a Year.

First, It has a diurnal Motion, which occasions the perpetual Succession of Days and Nights.

One Hemisphere of the Earth is always illuminated by the Sun; and the Circle of Illumination, or the Boundary of Light and Shade, is perpendicular to the Plane of the Ecliptic.

When any Point on the Globe first gets into the enlighten'd Hemisphere, the Sun is just risen to that Part; when it gets half Way, or to its greatest Distance from the Circle of Illumination, it is then Noon; and when it leaves the enlighten'd Hemisphere, it is then Sun-set *. But still it enjoys

* In Reality the Sun rises, in Appearance, sometime before the Place on which he rises is got within the Hemisphere that is obverted to the Sun; and he does not set 'till sometime after it has left that Hemisphere: which is occasioned by his Rays being refracted, or bent, in passing through the Earth's Atmosphere. And as the Degree of the Refraction at the Horizon is about 34 Minutes, which is more than the Sun's Diameter, his whole Body becomes visible before he is risen; that is, before a right Line drawn from even the upper Edge of the Sun's Disk could reach the Eye of the Observer? and in the same Manner he

48 *Of the Earth, and its Motions.* Part II.

joys some Light from the Sun, reflected by the Atmosphere, or Air, until it is got 18 Degrees beyond the Circle; which glimmering Light is called *Twilight*.

Suppose a *Peach* to represent the Earth, the *Down* on the *Peach* will fitly enough represent the Atmosphere; the Height of which is computed at about *fifty Miles*: for when the Sun is got 18 Days below the Horizon, his Rays will not reach lower than about 50 Miles over our Heads, and then we find the Twilight is gone, and we can see the smallest Stars that are visible to the naked Eye. So that there does not seem to be any Air above that Height to reflect the Light of the Sun to us.

N. B. Those Parts of the Earth that lie at more than 48 Degrees Latitude, have no perfect Night at all, at the Season of their longest Days, but Twilight only.

As the Earth moves round its own Axis, from West to East, in twenty-four Hours, all the heavenly Bodies must appear to move round the Earth, from East to West, in the same Time.

The Rays of the Sun, when he is near the Horizon, pass thro' a much larger Body of Air, by which the Force of the Light

he continues to be visible after he is set. Hence the Length of Days is somewhat more than is expressed in the Tables of the Sun's rising and setting.

Ch. 2. *Of the Earth, and its Motions.* 49

is much weakened, than when he is near the Zenith.

Hence it is that we can look upon the Sun, at his rising, or setting, without hurting our Eyes, which we are not able to do when he is at the Meridian. Let OBF represent the Earth, aLm the Orb of Air, or the Atmosphere which Fig. III. furrounds it. Let O be the Place of Observation, a m the apparent or sensible Horizon: Then Oa is the Length of that Portion of the Atmosphere, thro' which the Sun is seen at the Horizon, which is longer than Oi , thro' which he is seen in the Zenith*.

From hence also we may perceive the Reason why the Sky (which is nothing else but the terrestrial Atmosphere, thro' all Parts of which either the Rays of Light are transmitted to us from the heavenly Bodies, or they are reflected to us from it) appears not as an Hemisphere, but a depressed Arch, as aim .

Hence also the Reason is evident, why a Degree of the Sky, at or near the Horizon, appears longer than a Degree at or near the Zenith; and why Degrees shorten in their Appearance from the Horizon to the Zenith: For though the Angles HOS ,

* Eucl. III. 7.

DOE, and VOZ, are all equal, each of them measuring the same Number of Degrees on the Arch of the Circle in the Heavens ADZ*, yet the Portion of the Sky ab is greater than cd ; and that again is greater than the Portion ei .

From hence, perhaps, may arise the Cause of the Sun and Moon, and the Starry Constellations, appearing so much larger when they are seen near the Horizon, than when they have considerable Altitude. Let HS represent the Sun at the Horizon, VZ the Sun at the Zenith; now when the Sun is at the Horizon, the Portion of the Sky ab is enlightened by his Rays passing directly from the Body of the Sun to the Eye at O; or a Cone of Air, whose Base is ab , and whose Vertex is O, is illuminated with his direct Rays, while his Light is only reflected to the Eye at O, from all the other Parts of the Atmosphere. But when the Sun is in the Zenith, he is

* Tho' the Arch ADZ is, in this Figure, an Arch of a Circle described on the Center T, not on O, as it should be on Supposition that HS and VZ contain the same Number of Degrees, and therefore that the Angles HOS and VOZ are equal: Yet the Distance betwixt T, the Earth's Center, and O, on its Surface, being next to nothing, in Comparison with the Distance of a Circle in the Heavens, represented by the Arch ADZ, from the Earth, (as it will be shewed presently) it is much one, in this Case, whether that Arch be described on the Center T, or O: And therefore the Angles HOS, DOE and VOZ may very well be considered as all Equal.

seen directly thro' the smaller Portion of the Sky ei , and only the lesser Cone eiO is illuminated with his direct Rays. And as 30 Minutes of a Degree (which is nearly the Sun's apparent Diameter) appear shorter toward the Zenith, than toward the Horizon; therefore the Diameter and Disk of the Sun, appears less at his Meridian Altitude, than when he is rising or setting.

Or perhaps we may more easily conceive the Matter thus. When the Sun is in the Horizon, that Portion of the outward Surface of the Atmosphere which receives its Rays, that are transmitted thro' it directly to our Eyes is larger, and consequently receives a larger Bundle of Rays than when he is higher; therefore he appears to us so much larger when he is rising and setting, than at his Meridian Altitude.

This Figure may further shew, how the sensible and the rational Horizon approach nearer to be the same, the further an Object is off from the Earth. For though the Distance betwixt them is always the same, *viz.* TO , or a Semidiameter of the Earth; yet the greater the Circle is in which the Object is seen, the less is the Semidiameter of the Earth in Proportion to it. Thus TO bears a much greater Proportion to the Semidiameter of the Earth's Atmosphere, *viz.* Ti , than to TZ , the Semidiameter of the larger Circle.

52 *Of the Earth, and its Motions.* Part II.

Therefore in Circles so remote as the Orbits of the heavenly Bodies, the Distance betwixt the sensible and rational Horizon is not perceptible, but they may be considered as one and the same; the Semidiameter of the Earth being indeed but a Point, in Comparison with those vast Distances.

Secondly, The Earth has an annual Motion round the Sun, which produces the lengthening and shortening of Days, and different Seasons, *viz.* *Spring, Summer, Autumn and Winter.*

The Earth, in its annual Motion, has its Axis always in the same Direction, or parallel to itself.

The Earth completes its Revolution round the Sun in 365 Days 5 Hours and 49 Minutes. The odd 5 Hours and 49 Minutes, being nearly a Quarter of a Day, occasion the additional Day every fourth Year, or *Leap Year*. But yet as 4 times 5 Hours and 49 Minutes wants 44 Minutes of a compleat natural Day, or 24 Hours, (which Defect amounts to about 3 Days in 400 Years,) this occasions the Error of the Old Style, which is at present 11 Days behind the New Style, that is used in foreign Countries; and in 400 Years more it will be 14.

The Earth's annual Motion is from West to East; and in the same Course does the
Sun,

Ch. 2. *The Motions of the Earth.* 53

Sun, as seen from the Earth, appear to move thro' the Signs of the Zodiac.

In whatever Sign the Earth would appear, if seen from the Sun; the Sun appears in the opposite Sign, as seen from the Earth.

The Sign which the Earth is in, is that which appears upon the Meridian at Midnight; from whence we can tell what Sign the Sun is in, tho' we do not see the Stars at the Time of his shining.

When the Earth enters the Sign *Libra*, the ~~Sun~~ appears to enter the Sign *Aries*, which is about the 10th of *March*. Now the Circle of Illumination touches both Poles: the Sun is vertical to the Equator, and Days and Nights are equal all the World over. This is called the *vernal Equinox*.

When the Earth enters *Scorpio*, the Sun enters *Taurus*. Now the Days are lengthened every where North of the Equator, and shortened South of it.

While the Sun is, in Appearance, travelling thro' *Gemini*, the Days and Nights grow still more unequal.

When he arrives at *Cancer*, the Days are at the longest in the Northern Hemisphere, and at the shortest in the Southern. Now the whole Northern Frigid Zone is got within the Circle of Illumination towards the Sun; consequently there is no Night there.

there. The Reverse is the Case in the Southern Frigid Zone. Now the Sun is vertical to the Northern Tropic, which, from his entering the Sign Cancer at this Season, is called the *Tropic of Cancer*. This is the *Summer Solstice*.

As the Sun proceeds thro' *Leo* and *Virgo*, the Days shorten in the Northern, and lengthen in the Southern Hemisphere.

When he arrives at *Libra*, the Days and Nights are again every where equal. This is called the *Autumnal Equinox*, which falls out about the 12th of *September*.

When he comes to *Capricorn*, it is the longest Day in the Southern, and the shortest in the Northern Hemisphere. This is the *Winter Solstice*. The Southern Tropic is called the *Tropic of Capricorn*, for the same Reason that the Northern is called the *Tropic of Cancer*.

As the Sun proceeds thro' *Aquarius* and *Pisces*, the Days lengthen North of the Equator, and shorten South of it; until he arrives at *Aries* again, when the Earth has completed her annual Orbit, and Days and Nights are again every where equal.

The nearer any Place is to the Pole, it has the longer Days in the Summer, and the shorter in the Winter. At the Pole the longest Day is six Months.

In all Positions of the Earth, half the Equator is always in the Light, and half
in

in Darknes; therefore at the Equator the Days and Nights are always equal.

The Sun's Declination does not alter so fast; or his ~~Altitude~~, as seen from any Place on the Earth one Day at Noon, does not differ so much from his Altitude the next Day at Noon, when he is at or near the Solstices, as when he is at or near the Equinoxes: because the Ecliptic, in which the Sun appears to move, approaches much nearer to a parallel Position to the Equator, where it touches the Tropics, than where it cuts the Equator; and therefore neither does his diurnal Arch, or his apparent Path over the Earth above the Horizon, grow so much bigger or less; one Day than another; nor, consequently, do the Days lengthen, or shorten, so fast about the solstitial, as at the equinoxial Seasons.

The Sun, standing out of the Center of the Earth's annual Orbit*, makes the Summer to the Northern Hemisphere, longer than the Winter by eight Days: That is, from

* The Earth's Orbit is in Reality an Oval, or Ellipse, having the Sun standing in one *Focus*. The *Focus's* of an Ellipse are two Points in the longer Axis, equally distant from the Center, or Middle of it; from each of which, if a right Line be drawn to any Point in the Circumference, both those Lines together are equal to the longer Axis. The longer an Ellipse is, in Proportion to its Breadth, or the more it differs from a Circle, it is said to be the more *Eccentric*, and the *Focus's* are the further asunder, and nearer

56 *The Motions of the Earth.* Part II.

from the vernal Equinox to the autumnal, is eight Days more, than from the autumnal to the vernal.

The Sun being nearer to the Earth in our Winter, than in Summer, makes the Winters warmer, and the Summers cooler, than they are in the same Latitude South of the Equator. Hence also the Sun appears bigger to us in Winter than in Summer.

The Cause of greater Heat in Summer than in Winter is, partly, the Sun's being *longer* above the Horizon; and chiefly, his being *higher* above the Horizon; consequently his Rays come to the Earth in a Direction more perpendicular to its Surface in the Summer, than in the Winter.

Fig. IV. Let A B represent a Portion of the Earth's Surface, on which the Sun's Rays fall perpendicular; let A C represent an equal Portion, on which they fall obliquely, or asslant. It is manifest that A C, tho' it be equal to A B, receives but half the Rays, and therefore enjoys but half the Light and Heat that A B does.

nearer to the Ends. The *Focus* of the Earth's annual Orbit, in which the Sun stands, is that which is nearer to that End where the Earth is at the Winter Solstice. That Point of the Earth's, or of any Planet's Orbit, wherein it is nearest the Sun, is called its *Perihelion*. The opposite Point, in which it is furthest off from the Sun, is called its *Aphelion*.

More-

FIG. II

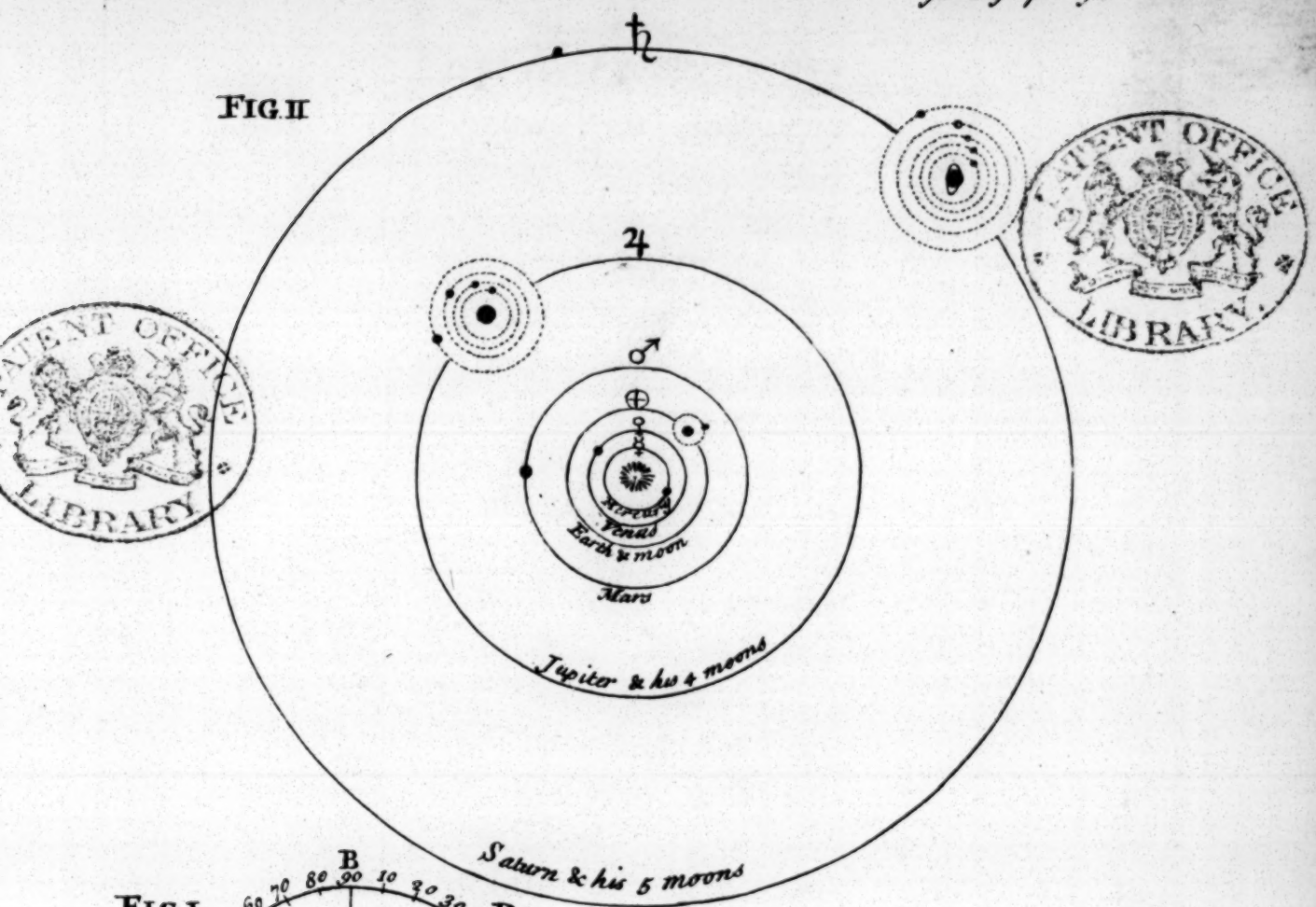


FIG. I

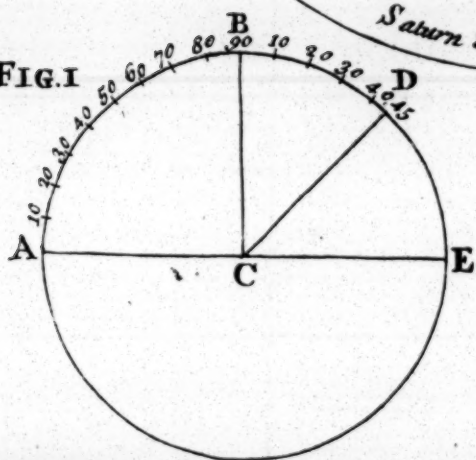
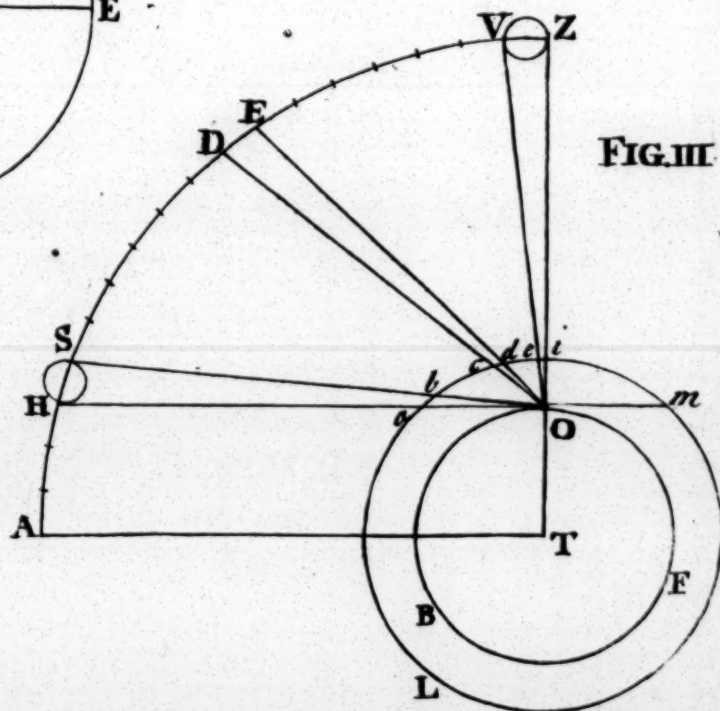


FIG. IV.



FIG. III



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Moreover the Sun being low, and near the Horizon in the Winter, his Beams pass thro' a much greater Quantity of Air in their Passage to us, by which the Force of them is weakened, than when he approaches nearer to our Zenith in the Summer.

The torrid Zone, to one Part or other of which the Sun is always vertical, is therefore hottest.

The frigid Zones, tho' they have the longest Days, receive the Sun's Rays most obliquely, and are therefore coldest.

The temperate Zones, to which the Sun is never quite vertical, nor very oblique, enjoy the more moderate Heat.

But yet we do not find the hottest Season of the Year to be just at the Summer Solstice, when the Sun is longest and highest above the Horizon, but generally a Month or two after: which may be thus accounted for. We know that a Body once heated by the Sun, does not grow cold again instantaneously, but gradually: or the heating Particles which flow from the Sun, do not fly off again all at once, as soon as the Sun is withdrawn; but they fly off, or lose their Force, by Degrees. Now so long as more Heat comes from the Sun in the Day than is lost in the Night, the Heat of the Earth and Air will be daily increasing.

I

Suppose

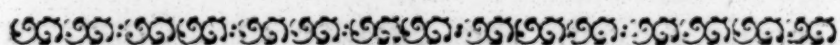
Suppose half the Heat of the Day should go off in the Night, and, for Example's sake, let us suppose that 100 heating Particles come from the Sun in the Day, 50 only of which fly off in the Night, when, at the Time of the Summer Solstice, the Night is but half as long as the Day. Suppose but 90 heating Particles come from the Sun the next Day; yet $90 + 50 = 140$. Suppose but 80 new heating Particles come the third Day; yet $80 + 70$ (*i. e.* half the Heat of the former Day) $= 150$; therefore this Day will be still hotter than the last. Thus while there are more Particles that excite Heat received in the Day time, than are lost in the Night, the Heat of the Earth and Air will constantly grow stronger. But, in Process of Time, as the Action of the Sun in heating grows weaker, and the Nights grow longer, more heating Particles will go off in the Night than were received in the Day; and then the Earth and Air will gradually cool again, till after the Winter Solstice.

The Earth does not move uniformly in its Orbit, or always with the same Degree of Velocity; but swifter when it is nearer the Sun, and slower when further off. The Medium betwixt the two Extremes of its swiftest and slowest Motion,

Ch. 3: *The Precession of the Equinoxes.* 63

tion, is called its *mean Motion* *; that is, such a Degree of Velocity, which as much exceeds the slowest Motion, as it falls short of the swiftest.

The Velocity of the mean Motion of the Earth in its annual Orbit, is computed to be at the Rate of $15\frac{1}{2}$ Miles in a Second of Time, 933 in a Minute, 56000 in an Hour: which is a 100 Times swifter than the Motion of a Cannon Ball. Any Point on the Earth's Equator moves, by the diurnal Rotation, at the Rate of about 17 Miles in a Minute, and 1020 in an Hour.



C H A P. III.

Of the Precession of the Equinoxes.

IN the last Chapter we supposed the Axis of the Earth to continue always in one immutable Position, or constantly parallel to itself; but it has been found by the Observations of many Years, that this is not precisely the Case; but that the Earth's Axis, tho' it always preserves the same In-

* As the Motion of all the primary Planets is sometimes accelerated, and sometimes retarded, according to their Distance from the Sun; and of the secondary Planets, according to their Distance from the primary Planets, about which they revolve; the Terms *mean Distance* and *mean Motion* are applicable to all of them.

60 *The Precession of the Equinoxes.* Part II.

clination to the Plane of the Ecliptic, yet deviates from its Parallelism, with a very slow retrograde Motion from East to West, at the Rate of 50 Seconds in a Year, or one Degree in 72 Years; whereby it describes a Circle, of $23\frac{1}{2}$ Degrees Radius, round the Pole of the Ecliptic, and completes its Revolution in 25920 Years. Suppose a Circle to be drawn in the Heavens of 47 Degrees Diameter, round the North Pole of the Ecliptic as its Center. Let the Axis of the Earth be produced to that Circle; then the End of the Axis would move round in that Circle, and the Axis itself would describe the Surface of a Cone, in one complete Revolution, whose Base is that heavenly Circle, and whose Vertex is at the Center of the Earth. Hence it follows, that all the fixed Stars in that imaginary Circle will, in their Turns, be Pole-Stars to the Earth; and that that which is now the Pole-Star, will, in Time, be 47 Degrees distant from the Pole. The Case is the same as to the South Pole; so that the Surfaces of two Cones are described, whose Vertexes meet at the Earth's Center.

Those two Points in the Earth's Orbit, where the Sun is vertical to the Equator, are always the *Equinoxial Points*: But as the Earth's Axis deviates from its Parallelism, those Points in its Orbit must also change their Places. Suppose the Direction
of

Ch. 3. *The Precession of the Equinoxes.* 61

of the Axis to be changed 90 Degrees; or that it now points to a fixed Star, in the imaginary Circle, 90 Degrees of the Circle distant from that which was formerly the Pole Star: It is evident that the equinoctial Points are *now*, where the solstitial Points were *then*; and that the *solstitial Points* are now moved into the former Places of the *equinoctial Points*. When the Axis has moved 180 Degrees, or thro' half the Circle, the *vernal Equinox* is got into the ancient Place of the *autumnal*, and the *Summer Solstice* into the Place where the *Winter* was formerly. When the *former* of these two Cases shall fall out, *viz.* when the Axis has moved 90 Degrees, the Summer and Winter will be of the same Length; whereas there is now eight Days difference betwixt them: when the *latter* shall come to pass, *viz.* when it has proceeded 180 Degrees, the Summer will be as much shorter than the Winter, as it is now longer; and the Sun will be furthest off from the Earth in our Winter, and nearest to it in our Summer.

As this Motion of the equinoctial and solstitial Points is backwards, or from East to West, contrary to the Order of the Signs of the *Zodiac*, the fixed Stars will appear to move the contrary Way; which they have done, since the Colures were first described, and the Asterisms drawn, by the
ancient

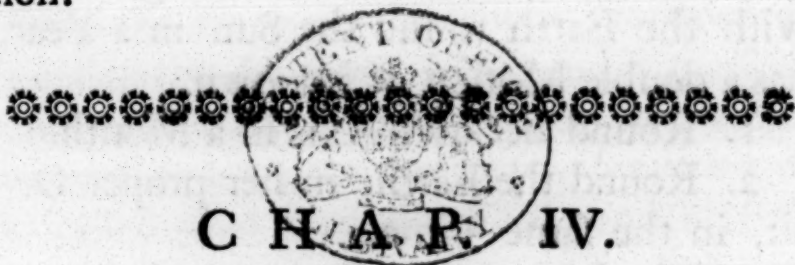
62 *The Precession of the Equinoxes. Part II.*

ancient Astronomers, (above two Thousand Years ago) about a whole Sign; so that the Stars which were then in that Portion of the *Zodiac*, which they named *Aries*, are now got into *Taurus*; and those that were then in *Taurus* are now in *Gemini*, &c. But tho' the Asterisms, or Constellations, have thus apparently shifted their Places; we still call the twelve Portions of the *Zodiac* by the ancient Names; v. g. we still call that the first Point of *Aries*, where the vernal Equinox now happens, tho' it is gone back to the Beginning of the Constellation *Pisces*; and we call that the first Point of *Cancer*, where the Summer Solstice now happens, tho' it is gone back to the Beginning of the Constellation *Gemini*.

From this Precession of the Equinoxes arises the Difference betwixt the *Siderial* and the *Tropical* Year, which will be taken Notice of Part III. For when the Sun is exactly in one of the Tropics, suppose the Tropic of Cancer, the Earth is not yet arrived to the same Point in the Heavens where it was, when the Sun was in the same Tropic last Year, by 50 Seconds of a Degree; and it will take 20 Minutes of Time to run thro' those 50 Seconds of a Degree, and to arrive at the same Star, or Point, in the Heavens, where it was at the last Summer Solstice. Hence the *Siderial*
Year

Year exceeds the Tropical Year by 20 Minutes.

The physical Cause of this Precession of the Equinoxes was unknown to all Astronomers, before the great Sir *Isaac Newton*; who has discovered, that it arises from the oblate sphaeriodical Figure of the Earth *, which is occasioned by its diurnal Rotation.



C H A P. IV.

Of the Moon.

THE Moon, which, of all the heavenly Bodies, next to the Sun, appears biggest and brightest, because of her Nearness to the Earth, on which she is a constant Attendant, is an opaque Globe, which has no Light of its own, but only reflects the Light of the Sun which shines upon it.

That the Moon shines only with a borrowed Light, may be concluded from her various Phases; for if she were a luminous Body,

* *i. e.* Its Diameter as the Equator is longer than from Pole to Pole; or its Shape is rather like an Orange than a Lemon, or a perfect Globe.

Body, like the Sun, she would always shine with a full Orb, as the Sun does.

The Moon's mean Distance from the Earth is about 240,000 Miles. Its Diameter is 2175 Miles.

One Hemisphere of the Moon is always enlightened by the Sun, while the other Hemisphere is in Darkness.

The Moon, besides her being carried with the Earth round the Sun in a Year, has a double Motion of her own.

1. Round her own Axis in a Month.
2. Round the Earth, in her proper Orbit, in the same Time.

1. The Moon's Revolution on her own Axis, once in a Month, certainly appears by her keeping the same Face always towards the Earth.

In the Moon the Days and Nights are each a Fortnight long, and always nearly of the same Length.

2. Of the Moon's Motion round the Earth.

The Orbit in which the Moon moves round the Earth is an Ellipsis, having the Centre of the Earth in one Focus. That Point of her Orbit wherein she is nearest the Earth is called her *Perigeon*, or *Perigee*; the opposite Point, in which she is furthest off from the Earth, is called her *Apogee*, or *Apogee*: these two Points are also called her *Apfides*; the one, viz. the *Apogee*,

Apogeon, is the higher *Apsis*, the other the lower *.

The Moon's Orbit is inclined to the Plane of the Ecliptic, making with it an Angle of about five Degrees.

The two Points where the Moon's Orbit coincides with the Plane of the Ecliptic, are called her *Nodes*.

The Node by which the Moon ascends above the Plane of the Ecliptic Northward, is called the *Dragon's-Head*, and is marked thus ☊. The opposite Node, by which she descends below the Ecliptic Southward, is called the *Dragon's-Tail*, and is thus marked ☋.

An imaginary Line, carried cross the Moon's Orbit, and reaching from Node to Node, is called *the Line of the Nodes*.

The Line of the Nodes appears continually to move in Antecedence, or contrary to the Order of the Signs of the Zodiac; and it revolves in nineteen Years.

The Moon can never appear exactly in the Ecliptic more than twice in her Period, *viz.* when she is in the Nodes.

The Moon's Distance from the Plane of the Ecliptic is called her *Latitude*; her greatest Latitude is 5 Degrees 18 Minutes.

* The same Terms are applied to all the other Planets. Any Planet is in its Apogeon, or higher Apsis, when it is furthest off from the Earth; and its Perigeon, or lower Apsis, when nearest to it.

66 *The Moon's Motions and Phases.* Part II.

As the Sun appears to pass thro' the twelve Signs of the Zodiac in a Year, so does the Moon in a Month.

When the Moon is in that Part of her Orbit which is nearest the Sun, she is said to be in Conjunction with the Sun. Then the Whole of her enlightened Hemisphere is turned from the Earth. Then it is *New Moon*.

When she has proceeded thro' one eighth of her Orbit, a little Part of her enlighten'd Hemisphere is turned towards the Earth, and she appears *horned*.

When she has advanced two eighths, she enters on her first Quarter; then we see a *half Moon*. When she has gained three eighths of her Orbit, she appears *gibbous* or *bumped*.

When she has proceeded thro' half her Orbit, the whole enlighten'd Hemisphere is towards the Earth; then she is said to be *full*, and in Opposition to the Sun. The Sun and Moon are then seen in the opposite Parts of the Heaven, one rising when the other sets. When she is advanced five eighths, she is again *gibbous*; but whereas the Defect or darkened Part was before toward the East, it is now toward the West.

When she has reached three Quarters of her Orbit, she enters on her last Quarter, and we see a *half Moon* again.

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At seven eighths she appears *horned*.

When she has completed her Revolution, the whole enlighten'd Hemisphere is again invifible, and we have another *New Moon*.

N. B. The Moon moves in her Orbit at the Rate of about 2300 Miles in an Hour.

The Moon performs a complete Revolution in her Orbit in the Space of 27 Days, and 7 Hours, which is called a *Periodical Month*; but the Earth having in this time advanced thro' almost a whole Sign in its annual Courfe, and carried the Moon along with it, the Moon will not come to the fame Pofition, with refpect to the Sun and Earth, as she was in when she began her Circle, until two Days afterwards. Thence it follows, that from New Moon to New Moon, which is called a *Synodical Month*, or *Lunation*, is 29 Days and a half, pretty nearly. Therefore, tho' in the Space of a Year the Moon performs 13 complete Revolutions round the Earth, or 13 periodical Months and 10 Days over; yet there are but 12 complete Lunations, or synodical Months, and 11 Days over, in a Year.

As the Moon, by reflecting the Light of the Sun, enlightens the Earth in the Night, fo does the Earth much more enlighten that Hemisphere of the Moon which is turned towards it; for the Surface of the

Earth being above fifteen times bigger than that of the Moon, probably reflects more than fifteen times as much Light as the Moon does to the Earth. From hence arises that dim Light which is visible in the darkened Part of the Moon a little before and after the Change. The Earth appears new and horned, gibbous and full to the Moon, just as the Moon does to the Earth, but fifteen times larger. When it is new Moon it is full Earth, and vice versâ.

The Moon proceeds daily in her Orbit about 13 Degrees, and loses about 48 Minutes a Day, one Day with another, in the time of her rising; but yet she loses more when she is in one Part of her Orbit, and less in another; which is occasion'd by the Moon's Path, (which, at present, we suppose to be the same as the Ecliptic) lying sometimes more oblique to the Horizon than at others. Suppose the Moon is in the Beginning of Aries when she rises to Day; To-morrow, when the Beginning of Aries comes again to the Horizon, the Moon is got 13 Degrees further Eastward, and therefore does not rise till sometime after. Now when the Ecliptic is in its most perpendicular Position to the Horizon, at the Time of the Moon's rising, 13 Degrees set her at a much greater Distance below the Horizon, than when it is in its most oblique Position; consequently

quently she will be longer in coming to the Horizon in the former Case, than in the latter. When the Beginning of Libra cuts the Horizon in the East, the Ecliptic is then in its most perpendicular Position to the Horizon; but when the first Point of Aries touches it in the same Place it is then in its most oblique Position. Consequently when the Moon is at, or near, the Beginning of Aries, at the Time of her Opposition to the Sun, or at full Moon, (which falls out about the autumnal Equinox,) there is then the least Difference in the Time of her rising from one Night to another, after the Full, that there is any Time of the Year. And if the Moon be at the same Time ascending from South to North Latitude, that will reduce her Path nearer to a parallel Position to the Horizon, by about 5 Degrees, than if she moved in the Ecliptic; and so make the Difference in the Time of her rising to be still less.

This full Moon is called the *Harvest Moon*; and it is remarkable for its varying so little in the Time of its rising for several Nights together, immediately after the Full.

If the full Moon happens just at the Equinox, or presently after it, the Ecliptic becomes more perpendicular to the Horizon, at the Time of the Moon's rising, every Day than other for many Days after;
and

and so long she loses more and more in the Time of her rising. But if the full Moon falls out before the Equinox, the Ecliptic grows more and more oblique to the Horizon at the Time of the Moon's rising; and she loses less and less in the Time of her rising every Day than other, till she arrives at the first Point of *Aries*. Now as that Week in the Summer or Winter, in which the Sun rises every Day nearest to the same Time, does not begin at the *Solstice*, but before it, and has the *solstitial Day* in the Middle of it; so that Week in the Year, next after a full Moon, when she rises every Evening nearest to the same Time, must begin not with the Moon's arriving at the first Point of *Aries*, (when the Ecliptic is in the most oblique Position of all to the Horizon at the Time of her rising,) but two or three Days before. Therefore it is, generally, that the full Moon in *August*, when she comes to her Opposition in *Pisces*, has most remarkably the Property of the *Harvest Moon*. And the next full Moon after, viz. in *September*, which has the same Property of rising nearly at the same Time, for several Nights after the Full, tho' not quite so remarkably as the former, is, by some, called the *Hunter's Moon*.

■ That the Surface of the Moon is very uneven and mountaneous, is apparent from

from the Irregularity or Unevenness of the Line which separates the enligthen'd from the dark Part of its Disk, at any Time when the Moon is not *full*; which Line, when viewed with a Telescope, appears, as it were, toothed, and cut with innumerable irregular Notches. And, besides, several shining Points may be seen in the dark Part of the Moon, quite separated, tho' not far distant from the enlighten'd Part. These are concluded to be the Tops of Mountains, which are sooner reached by the Sun's Beams than the lower Parts, that lie about them. The bright Top of one of these lunar Mountains has been observed, on the 4th Day after the new Moon, to be distant from the Confines of the enlighten'd Surface, about a 16th Part of the Moon's Diameter; from whence (supposing the true Measure of the Moon's Diameter to be known) it is easy to compute the Height of that Mountain; which is accordingly computed to be nine Miles high, that is, three times higher than the Top of any Mountain on the Earth.

Some Parts of the Moon's Surface, even when she is full, appear of a duskish Colour. These are supposed, by some, to be Seas and Lakes. But Dr. Keill asserts (vid. *Astron. Lectures*, Lect. 10.) " that when
 " they are looked at with a good Tele-
 " cope, they appear to consist of an Infi-
 " nity

72 *Eclipses of the Sun and Moon. Part II.*

“ nity of Caverns and empty Pits, whose
“ Shadows fall within them; which can
“ never be in a Sea, or liquid Body. These
“ black Spots therefore cannot possibly be
“ Seas: but they consist of some darker
“ and sad colour’d Matter, which does not
“ reflect the Light so strongly as the solid
“ and shining Mountains do.”

There seem to be no Clouds about the Moon: for when there are no Clouds in our Air, she constantly appears to us with the same Lustre.

C H A P. V.

Of the Eclipses of the Sun and Moon.

AN Eclipse of the Sun is occasioned by the Moon’s coming betwixt the Sun and the Earth, and thereby hiding the Light of the Sun from the Earth; which can only happen when the Moon is in Conjunction with the Sun, or at New-Moon.

An Eclipse of the Moon is occasioned by the Shadow of the Earth falling upon the Moon; or by the Moon’s passing thro’ the Shadow of the Earth, whereby she is necessarily darkened, and loses the Light of the

Ch. 5. *Eclipses of the Sun and Moon.* 73

the Sun. This can only happen when the Moon is in Opposition to the Sun, or at Full-Moon.

The Reason why the Sun is not eclipsed every New-Moon, and the Moon every Time she is full, is because of the Inclination of the Moon's Orbit to the Plane of the Ecliptic; so that an Eclipse can never happen, but when the Moon is either at or near one of the Nodes.

If the Moon happens to be exactly in the Node at the Time of her Conjunction, it occasions a *central Eclipse* of the Sun, which is commonly *total*; but sometimes, as when the Earth is in its *Perihelion*, and the Moon in its *Apogee*, the Eclipse will be *annular*; that is, a luminous Circle of the Sun will appear round the Body of the Moon.

If she be near the Node, the Eclipse may be *total*, tho' not *central*. If she be any where within $12\frac{1}{2}$ Degrees of the Node, she will hide at least some Part of the Sun from the Earth, and produce a *partial Eclipse*. If she be further from the Node than $12\frac{1}{2}$ Degrees, there will be no Eclipse at all; but the Light of the Sun will pass to the Earth, either under or over the Moon, without Obstruction.

So if the Moon be exactly in the Node at the Time of her Opposition, the Eclipse of the Moon, by the Shadow of the Earth,

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will

74 *Eclipses of the Sun and Moon. Part II.*
will be *central* and *total*. If near the Node,
total, tho' not *central*. If at a greater Di-
stance, but within $16\frac{1}{2}$ Degrees, the Sha-
dow of the Earth will fall upon Part of the
Moon, and occasion a *partial* Eclipse. But
if at a greater Distance than so, there will
be no Eclipse at all.

The Line of the Nodes being carried,
nearly parallel to itself, round the Sun in a
Year, would twice in the Year, if pro-
duced, pass thro' the Sun; and the New
and Full Moons which happen nearest to
such a Position of the Nodes will, most
commonly, produce Eclipses. So that there
are ordinarily four Eclipses in a Year, *viz.*
two of the Sun, and two of the Moon;
which fall out in Pairs, thus, one of each
Luminary at a Fortnight's Distance, and
another Pair, in the same manner, about
half a Year after.

The Shadows which both the Earth and
the Moon cast behind them, which cause
the Eclipses, are of a conical Figure, ter-
minating in a Point at a Distance from
their Bodies; which is proved thus:

If the Shadow of the Earth were a Cy-
linder, or every where of the same width,
(which must be the Case, if the Sun and
the Earth were of the same Bigness,) or if
it grew wider and wider the further it ex-
tended, (which would be the Case, if the
Earth were bigger than the Sun,) it would
run

Ch. 5. *Eclipses of the Sun and Moon.* 75

run out into infinite Space ; and sometimes it would involve in it, and eclipse the Planets *Mars, Jupiter* and *Saturn*. But, as that never happens, we may reasonably conclude, that the Shadow of the Earth is a Cone, whose Point, or Vertex, falls short of any of those Planets. Besides, it is found that the Moon is longer in passing thro' the Earth's Shadow, when she is in her Perigee, or nearer the Earth, than when she is in her Apogee, or further off from it ; which affords another Proof that the Shadow of the Earth is a Cone, which grows less the further it is extended ; and consequently this proves too that the Sun is bigger than the Earth.

If the Diameter of the Earth's Shadow, where it reaches the Moon, were not so long as the Diameter of the Moon (as would be the Case if the Moon were bigger, or as big as the Earth,) the Moon could never be totally eclipsed by it. But since the Moon is often totally eclipsed by the Shadow of the Earth, she must be less than the Earth, therefore much less than the Sun, and consequently her Shadow must also be conical.

The Shadow of the Moon where it reaches the Earth, is so small, that but a little Part of the Earth can be covered by it at a Time ; therefore a total Eclipse of the Sun can last no longer, in one Place, than

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about four Minutes. But the Diameter of the Earth's Shadow, where the Moon passes thro' it, is three or four Times longer than the Diameter of the Moon's Body; therefore the Moon is sometimes totally eclipsed for about three Hours together.

Since when the Moon is eclipsed, she is really darkned, and loses the Light of the Sun, from so much of her Disk as is involved in the Shadow of the Earth, a lunar Eclipse must appear just the same in all Parts of the World, where it is seen. But when the Sun appears eclipsed, he, in Reality, loses none of his Light, only the Moon stands in the Way of our seeing him, either wholly or in part. And since the Moon can hide the Sun but from a little Part of the Earth at one Time, a solar Eclipse will appear differently in different Places. In one Place it may be central and total, the Moon being just between that Place and the Sun, or that Place being just in the Center of the Moon's Shadow; while the Moon hides but part of the Sun from other Places; and from others, no part of him at all.

Thus in Fig. V. at all Places of the Earth between y and y the Sun is seen eclipsed, either totally or partially; between o and o the Eclipse is total; between e and e it is annular; at u the Sun appears half darken'd; but in Parts more remote from the
the

Ch. 5. *Eclipses of the Sun and Moon.* 77

the Center of the Shadow than y , there is no Eclipse at all.

A lunar Eclipse seen from the Moon, is an Eclipse of the Sun.

If a solar Eclipse (which is more properly an Eclipse of the Earth) can be seen from the Moon, it appears only as a dark Spot passing over the Disk of the Earth.

It is observed that the Moon, even when she is totally eclipsed, or wholly involved in the Shadow of the Earth, does not lose all her Light, but still appears of a faint dusky red Colour; which is owing to the Sun's Rays being refracted, or bent inwards, in passing thro' the Earth's Atmosphere, (just as they are in passing thro' a Burning-glass,) by which Means they enter, and, in some Measure, enlighten the conical Shadow of the Earth, where it involves the Moon; and it is by that faint Light that the Moon is still visible, even in the midst of a central Eclipse.

Astronomers divide the Diameters both of the Sun and Moon into twelve equal Parts, which they call *Digits*, and each Digit into Minutes, &c. by which they measure the Quantity of Obscuration, or the Bigness of an Eclipse.

C O R O L L A R I E S.

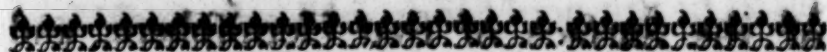
1. The Shadow of the Earth, which is visible upon the Moon in a lunar Eclipse,
appearing

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appearing always circular, is a sensible Demonstration of the globular Form of the Earth.

2. Since the Bigness of an Eclipse depends on the Bigness of the Shadow that falls on the eclipsed Body, and That on the Bigness, and Distance of the Body which casts the Shadow; and as the Time of an Eclipse depends on the Motions of those Bodies, it is evident that an Eclipse could not be computed before it happened, unless all these were known. But certain it is, that Astronomers are able to compute * Eclipses beforehand, to almost a Minute of Time; therefore we must conclude, that their Knowledge of these Matters is very considerable and certain.

* The Computation of Eclipses requires a great deal more previous mathematical Knowledge than the Persons, for whose Service this Treatise is designed, are supposed to be furnished with; therefore I wholly omit it. Those that would acquaint themselves with the Method of computing Eclipses, both solar and lunar, may see it in Dr. Gregory's or Dr. Keill's Astronomy. And they may find good Tables for calculating Eclipses in Dunthorne's *Practical Astronomy of the Moon*.

CHAP.



CHAP. VI.

The Doctrine of the Tides.

THE Surface of the whole Globe (as also its internal Parts) is every where pressed by Gravitation towards its Center.

If the Globe were all fluid, and some Parts of the Surface were more pressed than others, the Parts that were most pressed would be lowest, or nearest the Center; and the Parts least pressed would be highest, or furthest from the Center.

Both Sun and Moon attract the Earth with a Force which pervades the whole Globe; but the Moon's Attraction is much the stronger, by Reason of her being so much nearer to the Earth than the Sun is.

The Effects of the Moon's Attraction upon the Fluids of the Globe, to alter their natural spherical Figure, must be as follows:

First, Upon the Hemisphere towards the Moon; where the middle Point being nearest the Moon, and therefore most attracted by her, (directly contrary to its natural

tural Gravitation towards the Center) is less pressed by Gravitation than any other Part of the Surface of that Hemisphere, and consequently the Waters will there rise highest.

Secondly, Upon the Hemisphere that is remote from the Moon; where the middle Point being least attracted by the Moon, (by reason of its greatest Distance from her) is left behind, while all the other Parts, and even the Center itself, are more attracted towards her: from whence it will follow, that the Surface of the Water at the Middle of that Hemisphere, will be higher, or more remote from the Center, than in any other Part. The two middle Points will therefore be the highest in their respective Hemispheres; the one being really *more elevated*, the other *less depressed*, by the Moon's Attraction, than the adjacent Parts: So that these two Points may now be conceived of as the Summits of two opposite Mountains of Water, or the whole Globe may be conceived as now thrown into a spheroidical or oval Figure, whose longer Axis produced would pass thro' the Moon. And by reason of the Earth's Rotation, these Mountains must be continually shifting their Places all round the Surface of the Globe; from whence there will follow two *Flood-Tides* and two *Ebb-Tides* in the Space of 25 Hours; in which Time
the

the Moon moves from the Meridian of any Place, to the same Meridian again.

When the Sun and Moon are in Conjunction, or Opposition, that is, at New or Full Moon, the Attraction of both these Bodies acting upon the Earth in the same Direction, or in the same right Line, their Force is united to elevate the Waters; whereby are produced *Spring-Tides*.

When the Moon is in her Quadratures, her Attraction acts in one Direction, the Sun's in a quite contrary; by which Means they correct, or counteract one another, the Moon raising the Waters where the Sun depresses them, and vice versa; which produces *Neap-Tides*.

It is evident, that if the two opposite Protuberances, or Summits of the two Mountains of Water, were always exactly at the Poles of the Earth, there would be no rising and falling of the Waters by Means of the Earth's Rotation, or no Tides at all; but it would constantly be high Water at the Poles, and low Water all round the Equator. On the other Hand, when these two Summits are farthest from the Poles, that is, upon the Equator, the Rise and Fall of the Waters, by Means of the Earth's Rotation, is then greatest: therefore the nearer they are to the Equator, the Rise and Fall is the greater; and the nearer to the Poles, the

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Rise and Fall is the less. Consequently when the Sun and Moon are in Conjunction or Opposition, in or near the Equinoctial, as in *March* or *September*, the *Spring-Tides* must rise higher, (the Summits of the two Mountains being then upon the Equator) than when they are in Conjunction or Opposition in the Tropics, as in *June* and *December*. And the Moon being in the Tropics at her Quadratures in *March* and *September*, and in the Equinoctial at her Quadratures in *June* and *December*, the *Neap-Tides* will be less vigorous in the former Months, and more vigorous in the latter. And, besides, when the Moon is in the Tropics at her Quadratures, the Sun is in the Equinoctial; therefore the Rise and Fall of the Waters by his Influence (counteracting that of the Moon) is then greatest, tho' still less than that of the Moon, consequently the *Neap-Tides* will then be weakest. But when the Moon is in the Equinoctial at her Quadratures, the Sun is in the Tropic, whose Influence, as counteracting the Moon, is then least; therefore the *Neap-Tides* will then be strongest. So that the Difference betwixt the *Spring* and the *Neap-Tides* is much less considerable at the *solstitial*, than at the *equinoctial* Seasons.

Yet the highest Tides of the Year are observed to be (*cæteris paribus*) sometime
before

before the vernal, and sometime after the autumnal Equinox, *viz.* in *February* and *October*; which is owing to the Sun's being nearer the Earth in the Winter Months, when, consequently, the Force of his Attraction on the Waters is greater, than in the Summer Months.

It has further been observed, that, in this Part of the World, the Tides rise higher when the Moon is in the Northern Signs, at the Time of her coming to the Meridian, above our Horizon; and when she is in the Southern Signs at the Time of her coming to the Meridian, below the Horizon; than when, on the contrary, she is in the Southern Signs above our Horizon, and in the Northern Signs below it. The Reason of which will evidently appear upon the Globe, *viz.* That in the two former Cases, the Moon is nearer to our Zenith and Nadir, when she is upon our Meridian, or at the Time of high Water, and, consequently, we are then nearer to the Summits of the Mountains of Water, than in the two latter Cases.

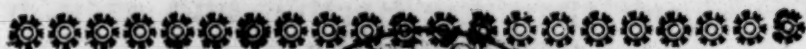
Tho' the Force by which the Tides are raised is continually increasing, from the Time of the Moon's Quadrature to her Conjunction or Opposition, after which it gradually decreases until the next Quadrature; yet the highest Spring-Tide is not just at the New or Full Moon, but a Day

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or two after ; which may be thus accounted for.

Conceive every Tide as raised by a double Force, *viz.* some Part of the Force by which the last Tide was raised still remaining, and the Force of a new Impulse. When both these together amount to more than the whole Force which raised the last Tide, the present Tide must rise higher than the last did. Suppose the remaining Force to be always half the whole Force of the last Tide : Suppose the new Impulse, just at New or Full Moon, to be 15, and the whole Force, with which that Tide is raised to be 22. Let the new Impulse of the next Tide be but 14, then $14 + 11$ (*i. e.* half 22) = 25 : this Tide will therefore rise higher than the last. Let the new Impulse of the next Tide be but 13 ; then $13 + 12\frac{1}{2}$ (*i. e.* half 25) = $25\frac{1}{2}$. Consequently this Tide will rise still higher than the last did ; tho' the Force of the Action of the two Luminaries, by which the Tides are raised, is now considerably abated.

For the same Reason, the deadeſt Neap-Tides will fall out, not precisely at the Moon's Quarters, but ſometime after.

CHAP.



C H A VII.



*Of the Planets Mercury, Venus,
Mars, Jupiter, and Saturn.*

THE Planets are distinguished into *Inferior* and *Superior*. Mercury and Venus are called the *Inferior* Planets, because they are lower than the Earth, in the solar System, and nearer to the Sun; Mars, Jupiter, and Saturn, are called the *Superior Planets*, because they are higher than the Earth, and more remote from the Sun.

MERCURY revolves about the Sun in 87 Days 23 Hours, at the mean Distance of 32,000,000 Miles. As this Planet is almost three times nearer the Sun than the Earth is, his Light and Heat is seven times greater than ours*; which Degree of Heat is sufficient to make Water boil.

* The Quantity of Light and Heat which the several Planets receive from the Sun, is reciprocally as the Squares of their Distances.

N. B. No Regard is here had to Atmospheres, or other Circumstances that may be peculiar to the several Planets, and which may possibly increase or diminish their Light or Heat, but merely to their Distances from the Sun.

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This Planet must therefore consist of denser Matter than the Earth; and if it be inhabited, it must be by other sort of Creatures than any that live here.

An Eye in Mercury sees five Planets superior to it. Venus and the Earth, when they are in Opposition to the Sun, shine upon Mercury with a full Orb, and afford a considerable Light to this Planet in the Night; but the other Planets do not afford him so much Light as they do to us.

It is not known whether Mercury revolves on his Axis, nor what is the Inclination of his Axis to the Plane of his Orbit; consequently the Length of his Days, and what Change of Seasons this Planet is subject to, are both unknown; only the Orbit of Mercury, being the most excentric of any of the Planets, must occasion a considerable Alteration of his Light and Heat, in different Times of his Year.

Mercury's greatest *Elongation*, or apparent Distance from the Sun, is about 28 Degrees. The Inclination of his Orbit to the Plane of the Ecliptic is 6 Degrees, 54 Minutes.

There may be other Planets betwixt Mercury and the Sun; but if there are, they can never be seen by us, because of their Nearness to the Sun.

VENUS,

VENUS, the brightest of the primary Planets, and nearest to the Earth, is 7906 Miles Diameter. She revolves on her Axis in 23 Hours* and in her Orbit round the Sun in 224 Days, 16 Hours, 46 Min. at the mean Distance of 59,000,000 Miles from the Sun. Her Light and Heat is more than twice as much as ours. The Orbit of Venus being nearer the Sun than the Earth's annual Orbit, she is much nearer the Earth, *viz.* six times nearer, at her *inferior Conjunction*, or when she is betwixt the Earth and the Sun, than at her *superior Conjunction*, *viz.* when the Sun is betwixt the Earth and Venus; therefore she appears much larger to us at one time than another.

Her greatest *Elongation* is about 48 Degrees. The Inclination of her Orbit to the Plane of the Ecliptic is 3 Deg. 24 Min.

She appears with different Phases, *viz.* *horned* and *full* like the Moon; and sometimes, at her inferior Conjunction, she ap-

* That is, according to *Cassini's* Observations, which he made in the Years 1666 and 1667. But *Sig. Francis Bianchini* has advanced a new Theory of Venus, according to which she performs her Revolution on her Axis in about 24 Days and 8 Hours; and the Inclination of her Axis to the Plane of her Orbit is 15 Degrees. He grounds this Theory on Observations which he made on that Planet in the Years 1726 and 1727, and has published it under the Title of *Hesperii et Phosphori nova Phænomena*. But I do not find it has yet been confirmed by the Observations of other Astronomers.

pears as a Spot passing over the Body of the Sun.

The different Phases of Venus were first discovered by the great Italian Philosopher *Galileo*, in the Beginning of the last Century: whereby he fulfilled the famous Prophecy of *Copernicus*; who, when it was objected to his Hypothesis, that according to it, *Venus ought to undergo the same Changes and Phases that the Moon does*, answered, that *perhaps the Astronomers in after Ages would find, that Venus does really undergo all these Changes.*

The inferior Planets, from the Time of their superior to the Time of their inferior Conjunction, are seen more *easterly* than the Sun, and set *after* him. Then they are *Evening Stars*.

But from the Time of their inferior to their superior Conjunction, they are seen *westward* of the Sun; and consequently set in the Evening, and rise in the Morning *before* him. Then they are *Morning Stars*.

They are seen from the Earth to move much swifter in their Orbits round the Sun at sometimes than at others; and their Motion at sometimes appears to be *direct*, or according to the natural Order of the Signs of the Zodiac, as from *Aries* to *Taurus*, &c. sometimes *retrograde*, or contrary to the Order of the Signs, as from *Taurus*

to *Aries*, &c. and sometimes they appear to be *stationary*, or without any Motion at all, for some Days together; all which is occasioned by the Earth and these Planets moving in concentric Orbits, one within another, but with different Velocities.

Let the lesser Circle about the Sun represent the Orbit of Mercury, and the larger the Earth's annual Orbit, about a Quarter, or 12 Weeks of which, answers, in time, to Mercury's Year. When the Earth is at o, and Mercury at o, in his Orbit, he appears at o in the Zodiac; about a Week after at 1 1 1, he appears *direct*; at 2 2 2 and 3 3 3 he continues *direct*, tho' more slow in his Motion; at 4 4 4 he is *stationary*; at 5 5 5 he appears *retrograde*, as also at 6 6 6 (when he is in his inferior Conjunction;) and at 7 7 7, till about 8 8 8, he is *stationary* again; after which, at 9 9 9 and 10 10 10, he becomes *direct* again; and more swiftly at 11 11 11 and 12 12 12. The Case of Venus is much the same. Fig. VI.

MARS, who looks the most red and fiery of any of the Planets, revolves on his Axis in 24 Hours, 40 Minutes, at the mean Distance of 123,000,000 Miles from the Sun. His Days and Nights are always nearly of the same Length; because his Axis is nearly at right Angles to the Plane

N of

of his Orbit. The Inclination of his Orbit, to the Plane of the Ecliptic, is 1 Deg. 52 Min. His Year is almost twice as long as ours, (for he performs his Revolution about the Sun in 1 Year, 321 Days, 23 Hours) but with little Variety of Seasons. The Quantity of Light and Heat which this Planet receives from the Sun is not half so much as ours. Mars seems to have an *Atmosphere* round him, as the Earth has, which is argued from the fixed Stars appearing obscure, when they are seen just by his Body.

This Planet is five times nearer to us when he is in Opposition to the Sun, than when he is in Conjunction with him; therefore he appears so much bigger and brighter at one time than another.

A Spectator in *Mars* will hardly ever see *Mercury*; unless sometimes as a Spot in the Disk of the Sun. To an Eye in Mars, *Venus* will appear about as far from the Sun, as *Mercury* does to us. And the *Earth* about as far off as Venus appears to us.

JUPITER'S mean Distance from the Sun is 424,000,000 Miles. He revolves on his Axis in 10 Hours; and his Days and Nights, each of 5 Hours, are always nearly of the same Length, all over his Surface; because his Axis, like that of Mars, is nearly at right Angles to the Plane
of

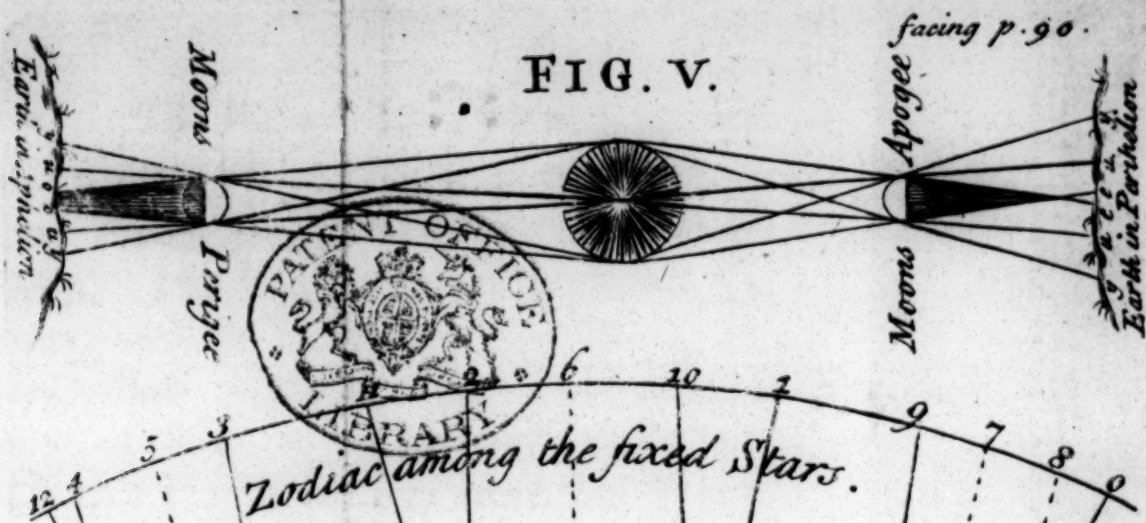
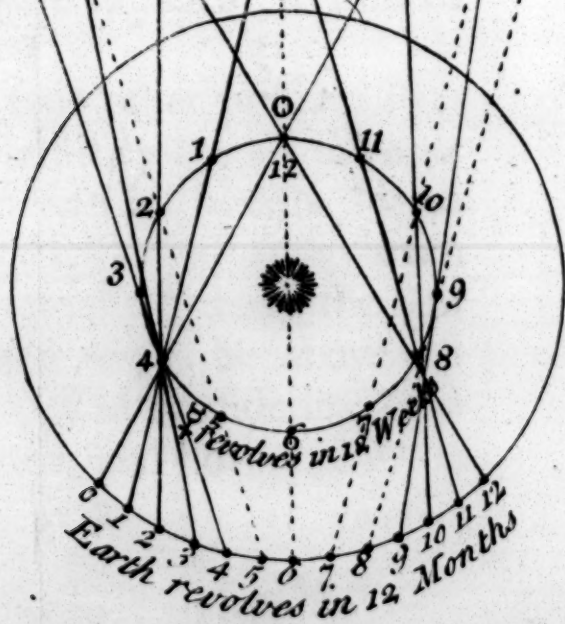


FIG. VI.



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Ch. 7. *The Planet JUPITER.* 91

of his Orbit. The Inclination of his Orbit, to the Plane of the Ecliptic, is 1 Deg. 20 Min. His Year is equal to almost 12 of ours, *viz.* to 11 Years, 314 Days, 12 Hours, but without any considerable Change of Seasons. The Light and Heat which this Planet receives from the Sun is but one 27th Part of what the Earth enjoys.

Besides abundance of Spots which may be seen on Jupiter's Surface, he appears to be surrounded with several *Belts*, or *Girdles*, which are parallel to his Equator, and to one another; and are variable both in respect to their Breadth, and their relative Distances. Sometimes they appear wider, sometimes narrower, sometimes they are nearer, and sometimes further off from one another. Whether these Spots and Belts are inherent in the Body of the Planet; or whether they swim, like Clouds and Vapours, in its Atmosphere, no Observations yet made are sufficient to inform us.

This Planet has four other primary Planets beneath him; but they are all too near the Sun to be ever seen in Jupiter by an Eye of no sharper Sight than ours: even Mars, which is furthest off from the Sun of all the four, will never be above 18 Degrees from him. And considering how small a Planet Mars is, and how weakly he

reflects the Sun's Light, he will scarcely be seen at so small a Distance from the Sun : so that Saturn is the only primary Planet that can be seen at Jupiter.

Jupiter has four Satellites or Moons revolving about him, *viz.*

		D : H : M		Miles.
First	Revolves in	1 : 18 : 28	at the Distance of	130,000
Second		3 : 13 : 14		364,000
Third		7 : 3 : 43		580,000
Fourth		16 : 16 : 32		1,000,000

His outermost Moon must appear almost as great to an Inhabitant of Jupiter (supposing his Eyes like ours) as our Moon does to us ; and if the other Satellites are not less than the outermost, they must appear much greater. Mr. *Hugens* conceives them to be not much, if at all, less than the Earth, In Jupiter they have frequent Eclipses of the Sun, and of their Moons ; and sometimes one Moon eclipses another.

All the four Satellites of Jupiter were first discovered by *Galileo*, Jan. 7, 1610.

SATURN's mean Distance from the Sun is 777,000,000 Miles, his Year is equal to near 30 of ours, *viz.* 29 Years, 167 Days, 22 Hours. The Inclination of his Orbit, to the Plane of the Ecliptic, is 2 Deg. 20 Min. Whether Saturn revolves on his Axis

Ch. 7. SATURN *and his Ring.* 93

Axis is not known: 'tis certain he enjoys but one 90th Part of the Light and Heat from the Sun that we do. An Eye in Saturn sees no primary Planet but Jupiter, which always appears to accompany the Sun.

Saturn has five Satellites moving round him, *viz.*

		D : H : M		Miles.
First	Revolves in	1 : 21 : 19	at the Distance of	146,000
Second		2 : 17 : 41		187,000
Third		4 : 13 : 47		263,000
Fourth		15 : 22 : 41		600,000
Fifth		79 : 22 : 4		1,800,000

The fourth Satellite is the largest of them all; the great disproportionate Space betwixt that and the fifth, gives Room to conjecture that there may be a sixth, tho' we have not yet discovered it.

The fourth Satellite was first discovered by the famous *Christ. Hugen*s, in the Beginning of the Year 1665. The other four were all discovered by Mr. *Cassini*, betwixt the Years 1671 and 1684.

Saturn has a vast solid Ring, different from all the other Planets, which encompasses his Body, as an Horizon does a Globe; it is about 21,000 Miles broad, and as much distant from Saturn's Body. The Thickness of it is to us almost invisible;

94 *Superior Planets, Direct, &c. Part II.*

ble; perhaps it may be 500 or 1000 Miles. This Ring casts a vast Shadow upon the Body of the Planet, and it must occasion very strange, and different celestial Appearances to the Saturnian Inhabitants, if any such there be.

The superior Planets, as well as the inferior, are, by Turns, Morning and Evening Stars; and they appear *direct*, *stationary*, and *retrograde*.

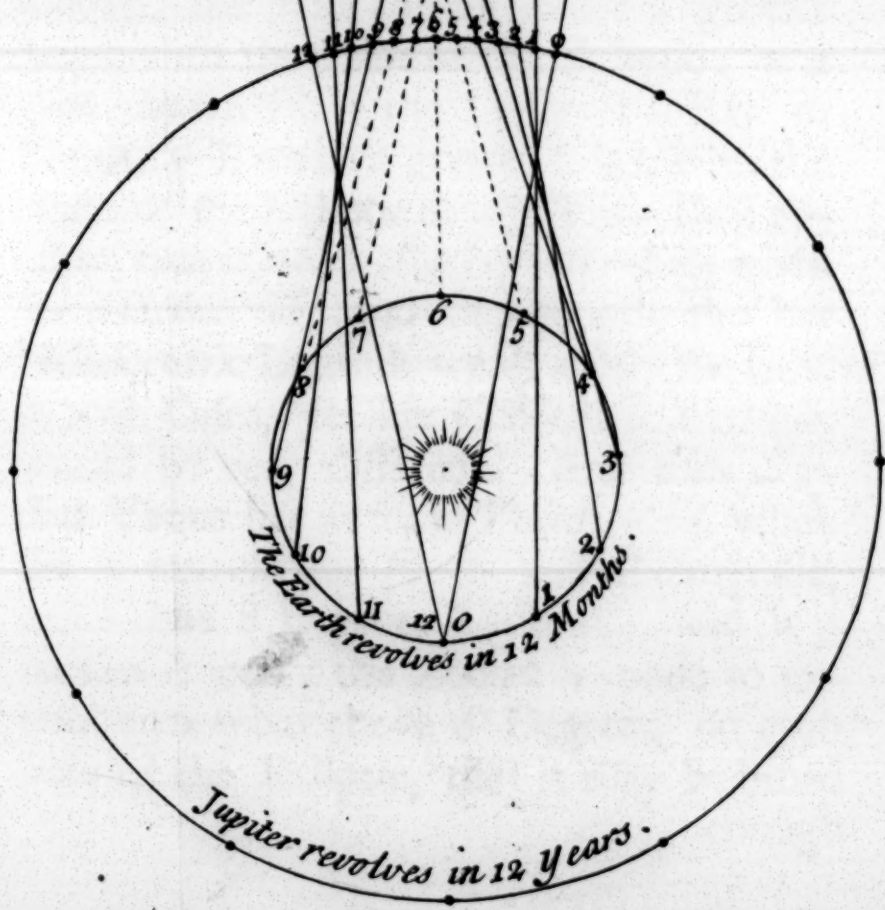
Let the lesser Circle about the Sun represent the Orbit of the Earth, and Fig. VII. the larger that of Jupiter, who moves thro' but about a 12th Part of his Orbit, while the Earth makes a complete Revolution round the Sun. When the Earth is at o, and Jupiter at o in his Orbit, he is seen at o in the Zodiac; about a Month after at 1 1 1, he appears *direct*, and near his Conjunction with the Sun; at 2 2 2 and 3 3 3 he continues *direct*, tho' more slow in his Motion; about 4 4 4 he is *stationary*; at 5 5 5 he appears *retrograde*; as also at 6 6 6 (when he is in his Opposition) and at 7 7 7, till about 8 8 8, he is *stationary* again; after which, at 9 9 9 and 10 10 10, he becomes *direct* again; and more swiftly at 11 11 11 and 12 12 12. The Case of Saturn and Mars are much the same.

As the Orbits of all the Planets are inclined to the Plane of the Ecliptic, some more

12 4 3 5 11 2 6 10 1 9 7 8 facing p. 94.
 Zodiac among the Fixed Stars.



FIG. VII.



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more and some less, they all have Latitude; that is, they are always at some Distance from the Plane of the Ecliptic, except when they are just in the *Nodes* of their Orbits. Their Latitude, as it would appear to an Eye placed in the Sun, is called their *Heliocentric* Latitude; as it is seen from the Earth it is called their *Geocentric* Latitude. Now, tho' the greatest *Heliocentric* Latitude of any Planet is but just equal to the Inclination of its Orbit to the Plane of the Ecliptic, yet its *Geocentric* Latitude may be much greater. For Instance, the greatest *Heliocentric* Latitude of Venus is about $3\frac{1}{2}$ Degrees; but as she is much nearer the Earth, at one Time than another, she will appear under a greater Angle with the Plane of the Ecliptic; or a Line drawn from the Observer's Eye to Venus, will make a greater Angle with the Plane of the Ecliptic at one Time than another, that is, when she is nearer than when she is farther off: and consequently tho' her *Heliocentric* Latitude were exactly the same in both Cases, yet her *Geocentric* Latitude would be very different. And thus it is, that Venus has at some Times, *viz.* when she is nearest the Earth and Retrograde, more than 8 Degrees Latitude; and it is on this Account the Zodiac is made to extend somewhat above 8 Degrees, on each Side of the Ecliptic, that it may be broad enough

enough to taken in the apparent Paths of all the Planets.

C O R O L L A R Y.

The *superior Planets* appearing *direct*, *stationary*, and *retrograde*, is a Proof of the Earth's annual Motion round the Sun ; for if it had no such Motion, they never could appear otherwise than *direct*.

That all the Planets, both primary and secondary, may be habitable Worlds, is a Notion, (however laugh'd at by the Vulgar, yet) not without a reasonable Probability. For who that has seen any Engine, a *Wind-mill* for Instance, in his own Country, and knows the Use of it is to grind Corn ; if he travels into another Country, and there sees an Engine of the same sort, will not reasonably conclude that it is designed for the same Purpose ? So when we know that the Use of this Planet, the Earth, is for an Habitation of various Sorts of Animals ; and we see other Planets at a Distance from us, some bigger, and some less than the Earth, all of them solid Bodies, much of the same Shape with the Earth ; one, at least, encompassed with an Atmosphere as the Earth is ; all moving periodically round the Sun ; most, if not all, of them revolving on their own Axis, just as the Earth does ; and some of them attended

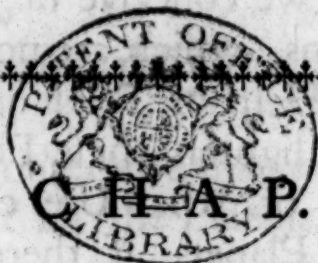
tended with Moons, to enlighten them in the Night: is it not highly reasonable to conclude, that they are all designed for the same Use that the Earth is, and that they are *habitable Worlds*, like this in which we live?

What Use can we conceive of Jupiter's and Saturn's Moons, which are not visible to us without the Help of Telescopes, unless they are to enlighten these Planets in the Night? And of what Use can their Light be to those Planets, if there be no Inhabitants to enjoy the Benefit of it? Nay, of how little Use are any even of the primary Planets to our World? How little is the Light which they afford us? And as for any Influence upon us and our World, which the *Astrologers* ascribe to them, which they conceit to be different, according to their different *Aspects* *, and by which they pretend to foretel future Events; it

* *Aspects* of the heavenly Bodies, signify their Situation in the Zodiac, with respect to one another; or their Distance from one another in Longitude. The Names and Characters of the different Aspects are

1. * *Sextile*, when they are two Signs, or 60 Degrees from one another.
2. □ *Quartile*, when they are three Signs, or 90 Degrees distant.
3. △ *Trine*, when they are four Signs, or 120 Degrees distant.
4. ☌ *Opposition*, when they are six Signs, or 180 Degrees distant.

it is most certainly all a groundless and foolish Conceit. Whoever considers the vast Distance of the Planets from us, and that their *Aspects* are according to natural Laws, will not easily believe they can have any such Influence at all.



VIII.

Of COMETS.

COMETS, or Blazing-Stars, were anciently supposed to be Meteors, or Exhalations, set on Fire in the highest Region of the Air; but the modern Astronomers have found that they are above the Orbit of the Moon. Most probably they are a sort of excentrical Planets, which move periodically round the Sun.

5. *Conjunction*, when they are in the same Sign and Degree.

N. B. Two Bodies are said to be in Conjunction when both are upon the same Line of Longitude, tho' they may not be in the same Point of the Heavens; but several Degrees distant from each other in respect of Latitude. Thus Mercury and the Moon may be in Conjunction, when yet they are 12 Degrees asunder; that is, when the former has near 7 Degrees Latitude on one Side of the Ecliptic, and the latter above 5 Degrees Latitude on the other Side.

their

Their Orbits are very long Ellipses, having the Sun in one *Focus* *.

The proper Motion of Comets is not the same in all, but each has its peculiar Course. Some go from West to East, others from East to West; some from North to South, others again from South to North, in all Planes and Directions: so that they are not, as the Planets are, contained within the Zodiac.

Not many more than twenty Comets have yet been observed; at least so as that their Paths in the Heavens have been traced and described. The Time in which they complete their Revolution is not yet known, except perhaps of two or three of them.

When the Comets descend near to the Sun, they become visible, and continue so for some time, while they are ascending again from him: but as they remove further off, we lose Sight of them by Degrees; 'till at length they run out into far distant Regions, where they are quite invisible to us, in by far the greater Part of their Orbits.

* Mr. *Azout*, a French Gentleman, was the first, that I can find, who pretended to predict the future Motion of a Comet; which he did upon observing the Path of one that appeared Jan. 1664, and of another that appeared the Year following. But our great and famous Sir *Isaac Newton* has since cleared up the Doctrine, and the Phenomena of the Comets, far beyond all that went before him, in his excellent *Princ. Philos. Mathem.* Lib. 3. Prop. 39. &c.

When a Comet descends near to the Sun it is set on Fire; and its Tail seems to be nothing else but a long and very thin Smoke, or Train of Vapours streaming from it, which always points to the Region opposite to the Sun.

The popular Division of Comets into three Kinds, *viz.* *Caudati* or *tailed*, *Barbati* or *bearded*, and *Criniti* or *hairy*, arises not from any real Difference of Comets from one another, but from different Circumstances of the same Comet. For Instance,

When a Comet is moving towards the Sun, the Train of Vapours follows it, like a *Tail*.

When it is moving from the Sun, after its Perihelion, the luminous Vapour marches before it, in the Manner of a *Beard*.

When the Vapour is projected directly behind the Comet from us, it is then hid from our View, excepting that we see a little of it appearing round the Comet, like a Border of *Hair*. This Appearance may be accounted for, partly, from the Train of Vapours widening as it recedes from the Head, (as it always does) so that we see a little of the remoter Part round the Body of the Comet; and partly, because the Vapour is raised, by the Heat of the Sun, chiefly from the Side or Hemisphere which
is

is towards the Sun, and is thrown off, by Gravitation, the contrary Way. For as in our Air, the Smoke of a heated Body ascends from the Earth, towards which the Body gravitates; so in the Heavens, where all Bodies gravitate towards the Sun, Smoke or Vapour must ascend from the Sun; therefore the Vapour which is raised from that Side of a Comet which is towards the Sun, is turned back again, and thrown the contrary Way. Consequently when the Comet is opposite to the Sun, and the heated Side is towards us, the Vapour, in returning back, is seen round the Edge of the Disk of the Comet, and helps to form what is vulgarly called the *Hair*.

N. B. The *Tail* or *Beard* of a Comet appears longer or shorter, not only as it is really projected to a further or less Distance from the Head, but as it appears to us making a greater or less Angle, with a Line drawn from our Eye to the Comet. When we see it at right Angles, or any great Angle, it appears long; but if at a small Angle it appears short.

Sir *Isaac Newton* has computed that the great Comet, which appeared 1680 and 1681, was heated, by its near Approach to the Sun, to the Degree of near 2000 Times the Heat of red hot Iron.

Bodies that can endure so intense a Heat, without being entirely diffipated and destroyed,

stroyed, must needs be very hard and solid; such therefore, no doubt, the Comets are.

Helvetius, by measuring the Comet that appeared 1665, found its Diameter to be three times as long as that of the Earth; consequently the Body of that Comet must be twenty-seven Times greater than the Earth*.

The Comet which appeared 1682, is supposed to be the same that appeared 1607, and before in 1531; whose Period must therefore be 75 or 76 Years; and whose Return may be expected 1758. Its greatest Distance from the Sun, to its least, is as 60 to 1: and its greatest Light and Heat, to its least, as about 3600 to 1.

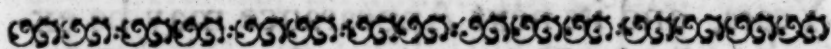
The Comet which appeared 1661, is supposed to be the same that appeared 1532, whose Period is therefore about 126 Years. It may be expected again 1789. Its greatest Distance to its least, is computed to be more than 100 to 1, and its greatest Light and Heat to its least, more than 10,000 to 1.

The great Comet which appeared 1680 and 1681 is supposed to be the same that appeared in the 44th Year before the Christian Æra, and again A. D. 531 or 532, again 1106, and lastly 1680; therefore

* Spheres are to one another as the Cubes of their Diameters.

the Time of its Revolution must be 576 Years, and its next Appearance may be expected in the Year 2256. Its greatest Distance to its least is above 20,000 to 1, and its greatest Light and Heat to its least above 400,000,000 to 1.

We know but little, or rather nothing certainly, of the Use of Comets. They seem, in their present State, to be very unfit for the Habitation of Animals; because of their intense Heat, when they are in one Part of their Orbit, *viz.* nearest the Sun, and their extreme Cold in the opposite Part. But yet God could, no doubt, make Creatures who should be capable of enduring both those Extremes. To imagine that the appearing of a Comet is ominous, and that it forebodes some approaching Calamity to any Part of the Earth, is a superstitious Conceit, without any Foundation in Reason; and it seems to be condemned in Scripture. *Jerem. x. 2. Thus saith the Lord, learn not the Way of the Heathen, and be not dismayed at the Signs of the Heaven; for the Heathen are dismayed at them.*



C H A P. IX.

Of the Equation of TIME.

AS the Moon wants two Days, over and above an entire Revolution in her Orbit, to complete a Synodical Month, or Lunation; (*vid.* Ch. iv. p. 67.) so, for the same Reason, does the Earth want about four Minutes, more or less, over and above an entire Revolution on its Axis, to complete a natural Day from Noon to Noon. Or thus: the Earth completes its Revolution in 23 Hours, 56 Minutes; but the Meridian on which it was Noon so long ago, is not yet come to Noon again; because, since then, the Earth has advanced forward, in its annual Orbit, about one Degree; and therefore we must wait some time longer, before the Sun will come again upon the same Meridian, and make Noon. But now *that* Meridian will at sometimes gain Noon again sooner, after a complete Revolution, than at other Times; sometimes in less than 4 Minutes, sometimes in more; because the Angle from the Sun to the two Points in the Earth's Orbit, the one where it was Yesterday

day

day at Noon, the other where it is to Day; when it has completed its Revolution, is less in Summer, when the Sun is farther off from the Earth, than in Winter, when he is nearer to it: and consequently, that Meridian will have the Sun upon it again sooner, after the diurnal Revolution is completed, when the Angle is less, than when it is greater; therefore the natural Days from Noon to Noon are not of equal Lengths, which is one Reason of the Difference betwixt *equal Time*, which is measured by a Clock that is supposed to go without any Variation, and to measure exactly 24 Hours from Noon to Noon; and *apparent Time*, which is measured by the apparent Motion of the Sun in the Heavens, or by a good Sun-Dial.

Let $AaCcF$ be the Earth's Orbit, S the Place of the Sun, Fig. VIII.
 $Aa = Cc$ the Arch which the Earth runs over, while it makes a complete Revolution on its Axis*. AB , a Semidiameter of the Earth from the Center to any Meri-

* The Arch Aa is in reality greater than Cc ; for the Earth, as well as every other Planet, describes in its Motion round the Sun, equal Spaces, or Areas, in equal times. That is, if the Earth moves from A to a , in the same Time that it moves from C to c ; the triangular Space ASa is equal to the Space $CS c$. But as the Triangle $CS c$ is longer than $AS a$, it is manifest that the Arch Aa must be greater than Cc . However it is sufficient, in the present Case, to suppose them equal.

dian at Noon Yesterday, in Winter; DC the same in Summer; ab the same Semi-diameter carried parallel to itself, after a complete Revolution, cd the same in Summer. Now the Angle $ASa = CSF$ (*Eucl.* I. 15.) is greater than $CS c$ by the Arch $F c$, therefore $d c e = CS c$ (*Eucl.* I. 29.) is less than $b a E = (ASa =) CSF$, therefore the Arch $d e$ is less than $b E$, therefore d will come to e in less time than b to E .

Another Cause of the Difference betwixt equal and apparent Time, is the *Obliquity* of the Ecliptic to the Equator; by Means of which, Archs of the Ecliptic, bounded by Meridians that are nearest to one another, are no where equal to Archs of the Equator, bounded by the same Meridians; but some are greater, others less: so that the Obliquity of the Ecliptic to the Equator, being greater in some Parts than in others, (*viz.* greater near the equinoctial Points, and less near the solstitial Points,) occasions also a Difference in the Length of natural Days.

Fig. IX. For let $E Q$ represent the Equator, $E Z Q$ a Semicircle of the Ecliptic; the Arch $E c$ upon the Ecliptic, (subtending the right Angle $E e c$) is greater than the corresponding Arch $E e$ upon the Equator by the little Arch $a c$: but the Arch $Z n$ upon the Ecliptic is less than the correspond-

corresponding Arch Cp upon the Equator by the little Arch no . For Zo is, by the Construction of the Figure, taken equal to Cp .

Suppose Ea ($=Ee = Zo = Cp$) to be so much of the Ecliptic as the Sun runs over in his apparent annual Course, while the Earth is performing one complete Revolution on its Axis: suppose he was Yesterday at E , when he made Noon upon the Meridian NES , he is now, after a complete Revolution of the Earth, arrived at a , and must therefore traverse the Line or Arch ab (by Means of the Earth's diurnal Motion) before he will make Noon again upon the same Meridian.

Suppose again that the Sun was at Z Yesterday, when he made Noon upon the Meridian $NZCS$; he is now, after a complete Revolution of the Earth, got as far as o , and must therefore traverse the Line or Arch om , before he will make Noon again upon the same Meridian. Now the Line om is longer than the Line ab , by how much the Arch of the Ecliptic Zo approaches nearer to a parallel Position to the Equator, than the Arch Ea : therefore (since the Earth always performs its diurnal Motion with the same Degree of Swiftmess) it will require more time for the Sun to traverse om , than ab . In the former Case, represented by om , the natural
P 2 Day

Day is more than 24 Hours long: then the equal Time gains upon the apparent Time, and Clocks that are well timed go faster than Sun-Dials. In the latter Case, represented by *ab*, the natural Day is less than 24 Hours: then the apparent Time gains upon the equal Time, and Clocks go slower than the Sun.

For the clearer Illustration of this Matter let it be considered, that if the Ecliptic lay due North and South, or perpendicular to the Equator, (on which Time is measured) the Motion of the Sun in the Ecliptic would make no Difference at all in the Length of natural Days, but every Day would be just 23 Hours 56 Minutes, and the Line or Arch *ba* or *ma* would be reduced to nothing.

On the contrary, if the Ecliptic lay parallel to the Equator, every natural Day would be exactly 24 Hours; and the Line *ab* and *ma* would be equal, each representing an Arch which the Sun traverses, in his apparent diurnal Motion, in just 4 Minutes. But as the Ecliptic is neither perpendicular nor parallel to the Equator; but in some Parts it approaches nearer to a Perpendicular, (as about the equinoctial Points,) and in other Parts it approaches nearer to a parallel Position, (as about the solstitial Points,) the Arch which the Sun traverses at the solstitial Seasons,

Seasons, to make Noon again after a complete diurnal Revolution, represented by om , must needs be longer than the Arch which he traverses, in the same Manner, about the equinoctial Seasons, represented by ab ; he will therefore be more than 4 Minutes in traversing the Arch om , and less than 4 Minutes in traversing the Arch ab .

From these two Causes, joined together, arises that Difference betwixt equal and apparent Time, which is expressed in the Tables of Equation; which show how much a Clock, if it were set exactly with a good Sun-Dial, when the equal and apparent Time are together, (as on the 4th of April, and supposing it to go at an equal Rate, measuring exactly 24 Hours a Day without any Variation) would go faster or slower than the Sun-Dial throughout the Year.

According to the first of these two Causes of the Difference betwixt equal and apparent Time, (*viz.* the Excentricity of the Earth's Orbit,) Clocks should go faster than the Sun in Winter, and slower in Summer. According to the second Cause (*viz.* the Obliquity of the Ecliptic to the Equator) Clocks should go faster than the Sun at the solstitial Seasons, and slower at the equinoctial Seasons. Now these two Causes, which are independent on each other, some-
times

times concur to increase the Difference betwixt equal and apparent Time, and sometimes they correct or counteract one another. Hence it is that though, according to the second Cause, Clocks should go slower than the Sun at both the equinoctial Seasons, and as much slower at one as at the other; yet they are about 7 Minutes faster than the Sun at the vernal Equinox, and about 7 Minutes slower at the Autumnal. The Reason is because Clocks have been losing of the Sun all the preceding Summer, according to the first Cause, which therefore concurs with the second Cause in Autumn, to make them go so much slower; whereas they have been gaining upon the Sun according to the first Cause all the foregoing Winter, which therefore counteracts and corrects the second Cause in the Spring.

It appears by the Tables, that six Weeks after the vernal Equinox, Clocks are 3 Minutes slower than the Sun, which is 10 Minutes slower than they were at the Equinox; whereas six Weeks after the autumnal Equinox they are 16 Minutes slower than the Sun, which is but 9 Minutes slower than they were at the Equinox. The Reason why they have lost more in six Weeks after the vernal Equinox than after the Autumnal is because, according to the first Cause, Clocks begin to lose of the Sun immediately

FIG. VIII.

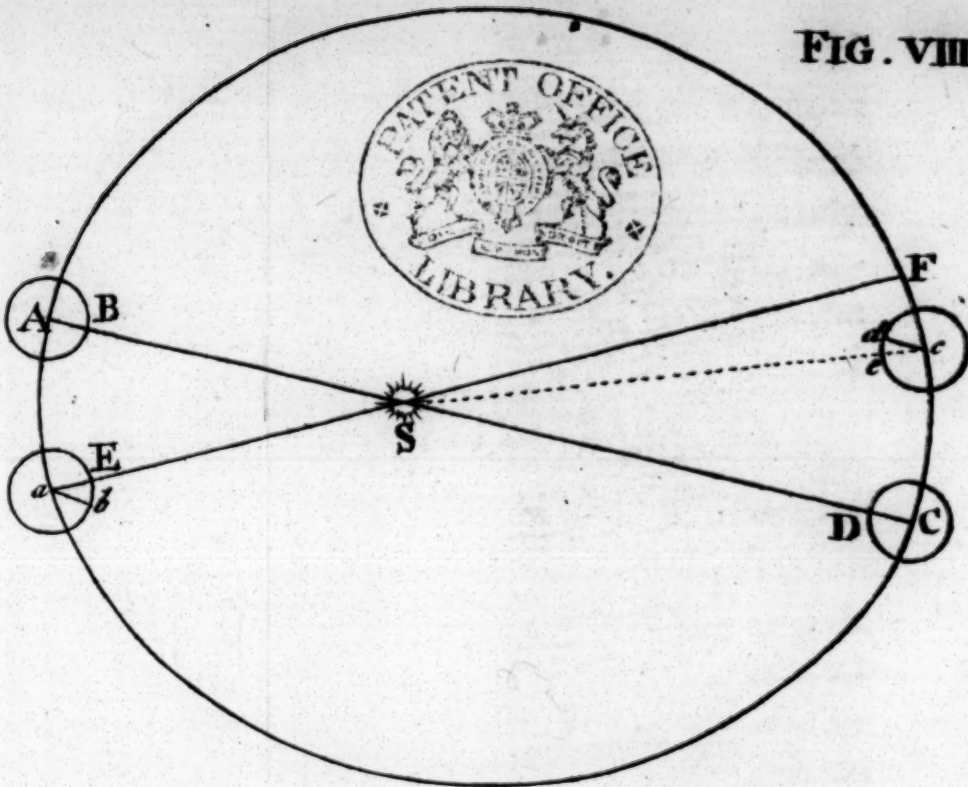
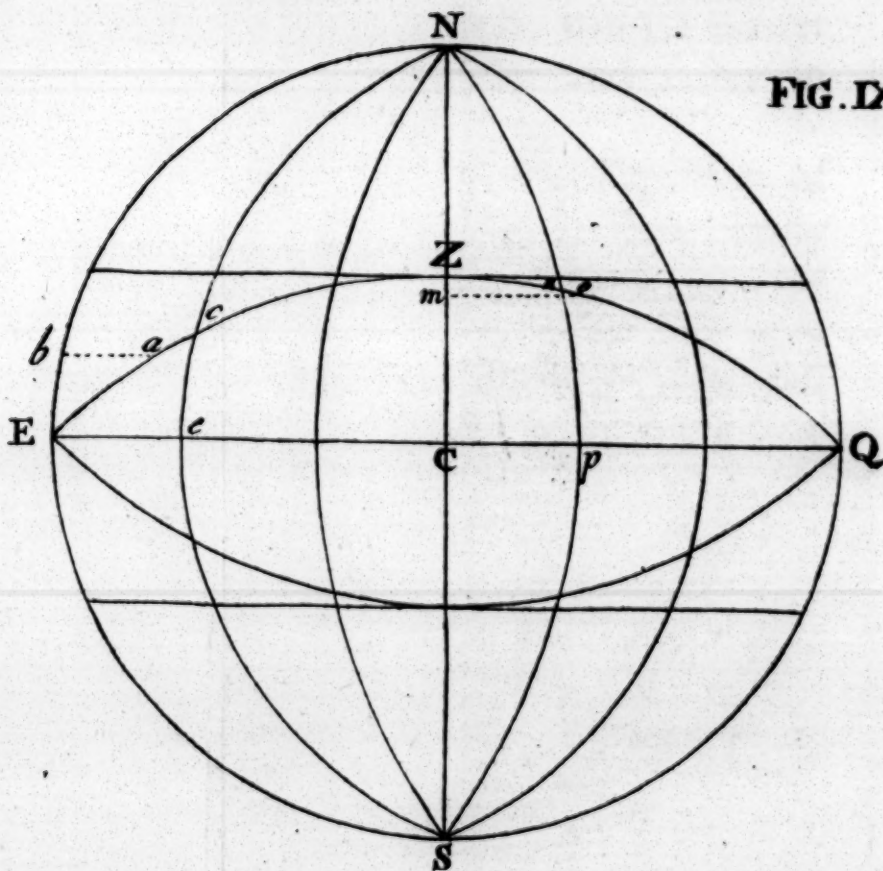


FIG. IX.



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Ch. 9. *The Equation of Time.* III

mediately after the vernal Equinox ; that Cause therefore concurs with the second Cause at that Season. But immediately after the autumnal Equinox they begin, according to the first Cause, to gain upon the Sun ; which therefore corrects the second Cause at that Season.

The former of these Causes of the Difference betwixt equal and apparent Time (*viz.* the Excentricity of the Earths Orbit) is affected by the Precession of the Equinoxes ; for though, according to that Cause, Clocks do, at present, go faster than the Sun in *Winter*, and slower in *Summer* ; yet in Process of Time the Earth will come to its Perihelion in the Summer, and then Clocks will go slower than the Sun in *Winter* and faster in *Summer*.

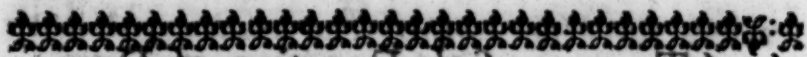
Therefore Tables of the Equation of Time, made for any Year, are continually afterwards deviating from Truth ; but yet the Precession of the Equinoxes is so very slow, that the same Tables may very well serve for an Age or more without any sensible Error.

A TABLE of the Equation of Days, shewing how much equal Time is faster or slower than apparent Time, throughout the Year.

Days	January		February		March		April		May		June	
	Faster		Faster		Faster		Faster		Slower		Slower	
	Min.	Sec.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	4	6	14	13	12	48	4	1	3	8	2	47
2	4	34	14	20	12	36	3	43	3	16	2	38
3	5	2	14	27	12	23	3	25	3	23	2	29
4	5	30	14	32	12	9	3	6	3	30	2	19
5	5	57	14	37	11	55	2	48	3	36	2	9
6	6	Equal	14	41	11	41	2	30	3	42	1	59
7	6	50	14	44	11	26	2	13	3	47	1	48
8	7	16	14	47	11	11	1	55	3	51	1	37
9	7	41	14	48	10	56	1	38	3	55	1	26
10	8	6	14	49	10	40	1	21	3	58	1	14
11	8	30	14	49	10	24	1	4	4	0	1	2
12	8	59	14	48	10	7	0	48	4	2	0	50
13	9	22	14	47	9	50	0	32	4	4	0	38
14	9	44	14	44	9	33	0	16	4	5	0	26
15	10	5	14	41	9	16	0	1	4	5	0	13
16	10	as	14	37	8	58	0	14	4	5	0	1
17	10	46	14	33	8	40	0	29	4	4	0	12
18	11	5	14	28	8	22	0	43	4	2	0	25
19	11	24	14	22	8	4	0	57	4	0	0	38
20	11	42	14	15	7	46	1	11	3	58	0	50
21	11	59	14	8	7	27	1	24	3	55	1	3
22	12	15	14	0	7	9	1	37	3	51	1	16
23	12	30	13	52	6	50	1	49	3	47	1	29
24	12	45	13	43	6	31	2	1	3	42	1	42
25	12	59	13	33	6	13	2	12	3	37	1	55
26	13	12	13	22	5	54	2	23	3	31	2	7
27	13	21	13	12	5	35	2	33	3	25	2	20
28	13	36	13	0	5	16	2	43	3	18	2	32
29	13	46			4	57	2	52	3	11	2	44
30	13	56			4	39	3	0	3	3	2	56
31	14	5			4	20			2	55		

A TABLE of the Equation of Days.

Days	July		August		September		October		November		December	
	Faster		Falter		Slower		Slower		Slower		Slower	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	3	8	5	46	0	* 18	10	23	16	13	10	32
2	3	19	5	42	0	Equal	36	10	42	16	13	9
3	3	31	5	38	0	55	11	0	16	13	9	45
4	3	42	5	33	1	14	11	18	16	12	9	20
5	3	52	5	28	1	34	11	36	16	10	8	55
6	4	2	5	22	1	Time	54	11	53	16	8	29
7	4	12	5	15	2	14	12	10	16	4	8	3
8	4	22	5	8	2	34	12	27	16	0	7	37
9	4	31	5	0	2	54	12	43	15	54	7	10
10	4	40	4	52	3	14	12	58	15	48	6	42
11	4	48	4	43	3	35	13	13	15	41	6	14
12	4	56	4	34	3	55	13	28	15	34	5	46
13	5	4	4	24	4	16	13	42	15	25	5	18
14	5	11	4	13	4	37	13	56	15	16	4	49
15	5	17	4	2	4	58	14	9	15	6	4	19
16	5	23	3	50	5	19	14	22	14	55	3	50
17	5	29	3	38	5	40	14	33	14	43	3	20
18	5	34	3	26	6	1	14	45	14	30	2	51
19	5	39	3	12	6	22	14	56	14	16	2	21
20	5	43	2	59	6	42	15	6	14	2	1	51
21	5	46	2	45	7	3	15	15	13	46	1	20
22	5	49	2	30	7	24	15	24	13	30	0	* 50
23	5	51	2	15	7	44	15	32	13	13	0	* 20
24	5	53	2	0	8	5	15	40	12	56	0	Equal
25	5	54	1	44	8	25	15	46	12	38	0	40
26	5	55	1	28	8	45	15	52	12	18	1	Time
27	5	55	1	11	9	5	15	58	11	58	1	40
28	5	54	0	54	9	25	16	2	11	38	2	10
29	5	53	0	36	9	45	16	6	11	17	2	falter
30	5	51	0	19	10	4	16	9	10	55	3	39
31	5	49	0	* 1			16	11			3	8
32												37



C H A P. X.

Of PARALLAXES.

THE Difference betwixt the *true Place* of the Sun, or Planet, and its *visible* or *apparent Place*, is called its *Parallax*. By the true Place is meant the Place where it would appear, among the fixed Stars, if it were seen from the Center of the Earth. The apparent Place is where it *does* appear, when seen from the Earth's Surface. This Difference is greatest when the Planet is at the Horizon, and gradually decreases as it rises higher, till, when it comes to the Zenith, it has no Parallax at all.

Fig. X. Let C be the Center of the Earth, O the Place of Observation on its Surface. Let Q P N represent a Quadrant of the Planet's apparent diurnal Path, and L V Z the Starry Firmament. Now when the Planet is at P, were it to be seen from the Earth's Center, it would appear in the Firmament at T; but to an Observer, viewing it from the Surface at O, it appears in the Horizon at H. The Arch

Arch HT , or the Angle HPT , or OPC , is called its *Horizontal Parallax*. When the Planet rises to S , the Arch VR , which is less than HT , measures its Parallax; at N it has no Parallax at all. These are called *Diurnal Parallaxes*.

The Angle which is formed by a Right Line, drawn from the Earth to the Sun, and from the Sun to the Moon, at either of her Quadratures, is called the *Menstrual Parallax* of the Sun. Fig. XL.

Dr. *Hook* and Mr. *Flamsteed* thought they had discovered an *annual Parallax* of the fixed Stars, of about $45''$; Fig. XII. that is, an Angle produced by two right Lines, drawn from the same fixed Star, to two opposite Points in the Earth's annual Orbit. But Mr. *Bradley* has since accounted for that supposed Parallax another Way. He conceives it to proceed from the progressive Motion of the Star's Light *.

The Sun, or a Planet's Distance from the Earth, and consequently its real Magnitude is found by its Parallax. For in every Triangle if *two Sides* and *one Angle*, or *one Side* and *two Angles* be known, all the other Sides and Angles are certainly found by Trigonometry. Thus in the Triangle OPC (Fig. X.) the Side OC

* *Philos. Transact.* N^o 406.

(which is the Earth's Semidiameter) being known, and the Angle at O, which is a right Angle; if the Angle at P can also be found, the Side PC, which is the Planet's Distance from the Earth, is also discovered. And the Distance being once known, the true Magnitude may be computed from its apparent Diameter. For, having the apparent Diameter, we can find, by the Help of trigonometrical Tables, what Proportion its real Diameter bears to its Distance, For let Fig. XIII. DE be the apparent Diameter, seen by an Eye at F; then as the Radius of a Circle is to the Tangent of the Angle DFE, so is the Distance FE to the real Diameter of the Object. And from the Diameter, the Magnitude of a Globe is easily computed.

Astronomers have contrived various Methods for finding the Parallax of the heavenly Bodies; for a Specimen of which take the following, from Dr. Keill's Astronomical Lectures, Lect. XXI.

In an Eclipse of the Moon observe when both its Horns are in the same vertical Circle, and then in that Moment take the Altitudes of both Horns: The Difference of these two Altitudes being ~~halft~~ and added to the least, or subtracted from the greatest, does give nearly the visible Altitude of the Moon's Center: But the true
 Altitude



FIG. X.

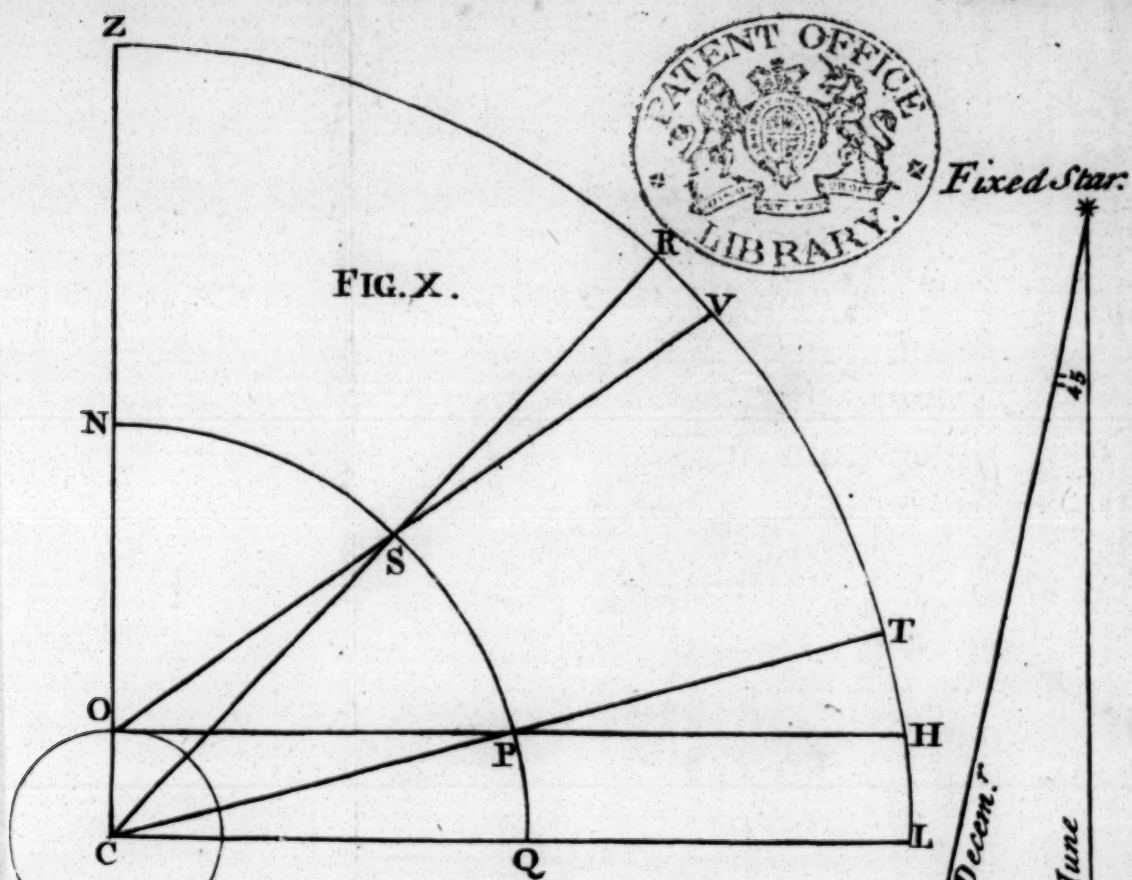


FIG. XI.

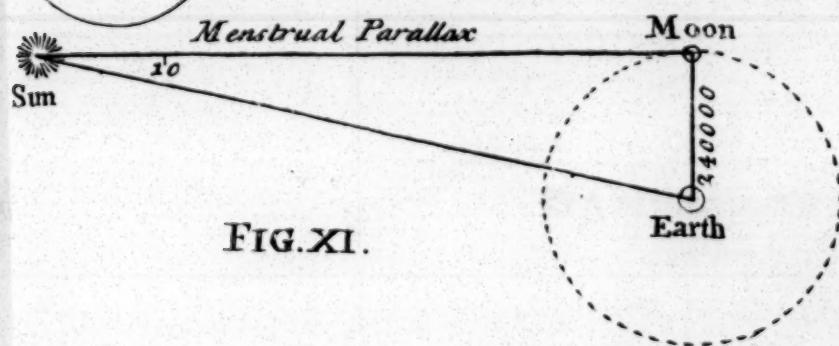


FIG. XII.

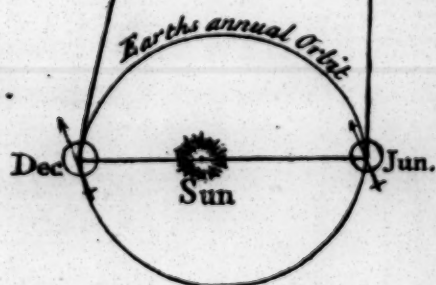
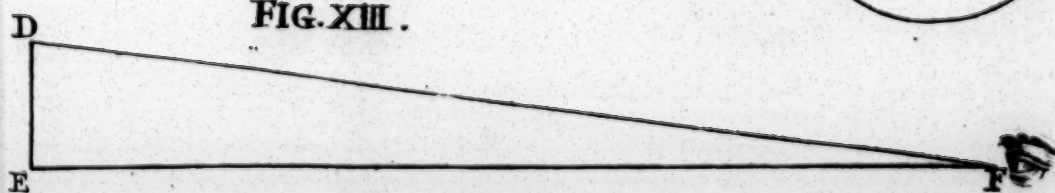
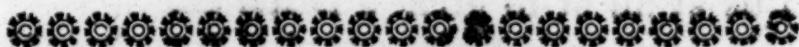


FIG. XIII.



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Altitude is nearly equal to the Altitude of the Center of the Shadow at that Time. Now we know the Altitude of the Center of the Shadow, because we know the Place of the Sun in the Ecliptic, and its Depression under the Horizon, which is equal to the Altitude of the opposite Point of the Ecliptic, in which is the Center of the Shadow. And therefore we have the true Altitude of the Moon and the apparent Altitude, whose Difference is the Parallax, which will therefore be known.



C H A P. XI.
Of the Fixed Stars.

THAT the Fixed Stars are at a very great Distance from the Earth, may be concluded from the North Pole of the Earth pointing as directly to the Pole Star*, when the Earth is at Aries, as when it is at Libra; tho' those two Points in the Earth's Orbit are at the Distance of 162,000,000 Miles from each other,

* The Pole Star is a Star of the second Magnitude, in the Tip of the Tail of the *little Bear*, and is very near the exact North Pole of the World.

which,

which, it seems, amounts to no more than an insensible Point, in respect to the Distance of the fixed Stars.

The fixed Stars being visible to us at such a vast Distance, makes it highly probable that they are very large Bodies.

They are probably also at vast Distances from one another, which may be one Cause of their appearing of such different Magnitudes. They seem, by the Lustre of their Appearance, to emit Light like the Sun; and, indeed, if they only reflected Light, they could hardly be visible to us at all at so great a Distance.

Scarce 2000 Stars can be seen by the naked Eye; but ten, or, perhaps, twenty times more, may be discerned by Telescopes.

Thus, in the *Pleiades*, where only six Stars are to be seen with the naked Eye, Dr. *Hook* counted 78 with a Twelve-foot Telescope; and with longer Telescopes he discovered a great many more. (See his *Micography*, p. 241.) And in the Constellation *Orion*, where but 62 Stars can be counted with the naked Eye, 2000 have been number'd with the help of Telescopes.

Can we think that God made these vast and numerous Bodies only to twinkle to us in the Night? Or is it not a more reasonable Conjecture that the fixed Stars are
all

all Suns with planetary Worlds moving round them, like our Sun? which, perhaps, is no other than one of the fixed Stars.

All the fixed Stars are like the Sun, immoveable in their Places, but all of them are not invariable as to the Lustre of their Appearance. Some of them appear and disappear periodically, as that in the Neck of the *Whale*, which is invisible for eight or nine Months in the Year; and in the other three or four Months of its Appearance, it is continually changing its Lustre and Brightness; which may, perhaps, be owing to the Star's being covered with dark Spots, such as we see in the Sun, over the greatest Part of its Surface. And, supposing it to have a Rotation on its Axis, like our Sun, but slower; it presents, at sometimes, its bright Part to our View, upon which it becomes visible; at other Times it turns its dark Side to us, and then we cannot see it.

New Stars have also been observed to appear, as one in the *Swan's Breast*, which was first taken Notice of by *Kepler*, in the Year 1600. And old Stars have disappeared, and become invisible. For Instance, one in the *Pleiades*, which were formerly seven Stars, and are called so still, though no more than six have been visible to the naked Eye for several Ages past. It
seems

seems the seventh was lost as long ago as Ovid's Time, by this Verse in the third Book of his *Fasti*,

Quæ septem dici, sex tamen esse solent.

and we are assured by the Catalogues of the fixed Stars, which were made by the ancient Astronomers, and even so late as by *Tycho*, that several Stars were observed by them, which are now become invisible. But whether these are periodical Stars, like that in the *Whale's Neck*, only with a slower Motion; or whether the new ones are new Creations; and whether the old ones, that have disappeared, are burnt out and extinguished; are Matters which surpass the Knowledge of the Philosophers of this World.

C O R O L L A R Y.

From this View of the fixed Stars, a probable Argument may be deduced for the Earth's diurnal Motion, *viz.* that such a Motion of the Earth is more probable, (as being more agreeable to the Wisdom of the divine Architect) than the diurnal Rotation of all the fixed Stars, as well as of the Sun and Planets, round the Earth. To illustrate this Argument, suppose but a hundred Men sitting round a great Room, attending on a Lecture of Geography, and a com-

a common Terrestrial Globe placed in the midst of them. Now which would be the best Way to shew all the Parts of the Globe to each Person successively? Whether by turning the Globe round its Axis; or, by a vast deal of Machinery and Wheel-work, to make the Room, and all the Seats in it, turn round the Globe? Which Way any wise and skilful Man would take, in this Case, is easy to determine.

It is a further Probability on the Side of the Earth's diurnal Rotation, that *Venus*, *Mars*, and *Jupiter*, are certainly known to revolve on their Axes; and it is highly probable the Earth does so too. As for *Saturn* and *Mercury*, the one is so remote from us, the other so near the Sun, that we have not been able to discover any Spots on the Surface of either of them, by which to judge whether they revolve on their Axes or no. Another and more certain Proof of the diurnal Rotation of the Earth is deduced from the Shape of it, which is an *oblate Sphæroide*, having its Diameter at the Equator above 30 Miles longer than from Pole to Pole. This, no doubt, arises from a diurnal Rotation; as it is certain that such a Rotation of the Earth must necessarily give it the same sphæroidical Form which it is found in Fact to bear.

R

As

As for those Scripture Expressions. The *Sun's rising* and *going down*, *running his Race*, *standing still*, &c. they are true and proper Descriptions of the Phænomena, as they appear to us ; but by what Motions those Phænomena are occasioned, these Expressions do not at all determine.

That some Part, at least, of the Account of the Sun and Moon's standing still in the 10th Chapter of *Joshua*, is merely a Description of the Appearance, is evident, in that the *Sun* is said to *stand upon Gibeon*, and the *Moon in the Valley of Ajalon*. Now *Gibeon* and *Ajalon*, and indeed the whole Land of *Canaan*, lies in too Northern a Latitude for either Sun or Moon ever to be vertical to, or directly over, any Part of it. However, this was a just Description of the Phænomenon as it appeared to *Joshua*, in the Place where he then was, where the Sun seemed to be upon *Gibeon*, and the Moon over the Valley of *Ajalon* ; (just as the Sun often appears to us to be directly over this or that Tree or Steeple, tho' we know the Place to which he is then really vertical is some Thousands of Miles off.) But if *Joshua* had been then in another Part of the Country, the Sun and Moon would have appeared to him, not as over *Gibeon* and *Ajalon*, but over other Places ; while yet, in Reality, neither of them were over any Place that he could
then

then see. Now if one Part of the Account, *viz.* that which respects the Place of the Sun, be nothing else but a Description of the Phænomenon, as it appeared, and not as it was in Reality: I see no Reason why the other Part, respecting the Sun's moving or standing still, should be understood any otherwise. And I should think it might as well be proved, from this Text, that the Sun did then depart from the Ecliptic, and came at least 7 Degrees Northward, to stand over *Gibeon*; as that, it is the Motion of the Sun, and not of the Earth, which occasions the Succession of Days and Nights.





P A R T III.
C H R O N O L O G Y.

C H A P T E R I.
Of the Divisions of TIME.



THE most common Divisions
of Time are into *Days, Hours,*
Weeks, Months and Years.

I. DAYS are either *Natural* or *Artificial.*

A *Natural Day* is the Space of Time
which flows while the Sun goes from any
Meridian to the same Meridian again; or
from any Hour one Day, to the same Hour
the next Day. These Days are always of
the same Length, very nearly.

An

An *Artificial Day* is from Sun-rise to Sun-set. These Days are of different Lengths, at different Times of the Year, all the World over, except at the *Equator* and the *Poles*.

Different Nations have begun the natural Day differently.

The *Jews* began the Day from Sun-set.
The *Babylonians* from Sun-rising.

The *Egyptians* from Midnight; in which they are followed by most modern Nations of *Europe*.

Only the *Astronomers* begin the Day at Noon, and count 24 Hours till the Noon of the next Day, and not twice twelve, according to vulgar Computation.

II. HOURS are also either *Natural* or *Artificial*.

A *Natural Hour* is the 24th Part of a *natural Day*. The Hour is divided into 60 *Minutes*; the Minute into 60 *Seconds*, &c.

An *Artificial Hour* is the 12th Part of the *artificial Day*, or *Night*. This was used by some of the Ancients.

III. A WEEK is a System of seven Days. The First is called *Sunday*, or *Lord's-Day*. The Second, *Monday*, &c. In Latin they are named after the Planets. *Sunday* is *Dies Solis*; *Monday*, *Lunæ*; *Tuesday*, *Martis*;

Martis; Wednesday, *Mercurii*; Thursday, *Jovis*; Friday, *Veneris*; Saturday, *Saturni* *.

IV.

* The ancient *Saxons* had a great many Idols, seven of which were appropriated to the seven Days of the Week, because of some Worship that was paid to each Idol on its respective Day, *viz.*

1. The SUN.

2. The MOON.

3. *TUISCO*, who had been a Man of great Renown among the *Germans*, after whom they called themselves *Tuitsben*, that is *Tuitsbmen*, from whence comes the modern Name *Dutchmen*. The *third* Day of the Week was especially dedicated to the Worship of this Idol, which was therefore called *Tuisday*, or *Tuesday*.

4. *WODEN*, who had been a famous Warrior, and was therefore honoured as the God of Battle, in like Manner as *Mars* was among the *Romans*. He was chiefly worshipped on the *fourth* Day of the Week, which was called *Wodensday*, or *Wednesday*.

5. *THOR*, the God who was supposed to govern the Winds and Clouds, and to whom they prayed for seasonable Weather, and that especially on the *fifth* Day of the Week, called therefore *Thorsday*, or *Thursday*.

6. *FRIGA*, a Goddess reputed the giver of Peace and Plenty, for which Gifts they prayed to her chiefly on the *sixth* Day, which was therefore called *Frigedead*; from whence comes the Name *Friday*.

SEATER, to whom they prayed for Protection, Freedom and Concord; and also for the Fruits of the Earth. He was worshiped on the *seventh* Day of the Week, which therefore received the Name *Seater-day* from this Idol; or as we now write it *Saturday*.

The *Romans* finding, or fancying, some Resemblance between the Attributes of those *Saxon* Idols, and several of their Gods, imagined them to be the same. As *Woden* they supposed to be *Mars*, *Thor* to be *Jupiter*, the Thunderer; *Friga*, to be *Venus* the Goddess of Love and Friendship; and especially because *Venus* was honoured by them on the same Day of the Week. *Seater* they mistook for

IV. MONTHS are either *Astronomical* or *Civil*.

The *Astronomical Month* is either *Lunar* or *Solar*.

The *Lunar Month* is that Space of Time which the Moon takes up in performing its Course thro' the Zodiac.

The *Solar Month* is that Space in which the Sun goes thro' one Sign, or 30 Degrees of the Zodiac.

The *Civil* or *Kalendar Month* consists of a certain Number of Days, according to the Laws or Customs of different Countries. The English, and most other European Nations, make 12 Months in a Year, viz. *January, February, March, April, May, June, July, August, September, October, November, December*.

The Number of Days in each Month is found by the following Canon.

Thirty Days hath *September,*
April, June, and November,
February hath Twenty-eight alone,
All the rest have Thirty-one.

for *Saturn*, merely because of the like sounding of the Name.

Vid. *Verstegan's Restitution of decayed Intelligence*, Page 68.

V. YEARS

V. YEARS are again either *Astronomical* or *Civil*.

The *Astronomical Year* is either *Solar* or *Lunar*.

The *Solar Year* is *Siderial*, or *Tropical*.

The *Siderial Year* is the Space that flows while the Sun is passing from any fixed Star, to the same again. It consists of 365 Days, 6 Hours, 9 Minutes, 14 Seconds.

The *Tropical Year* is the Space that flows while the Sun passes from either Tropic, or from any Point of the Ecliptic, to the same again. This is somewhat short of the *Siderial Year*, because every Point of the Ecliptic goes backwards about 50 Seconds of a Degree in a Year, (as was shewed Part II. Chap. 3.) thereby meeting the Sun, as it were; which makes the Sun return to the same Point of the Ecliptic, about 20 Minutes of Time before he arrives at the same fixed Star, where that Point of the Ecliptic was when the Sun was in it a Year ago. The *Tropical Year* therefore is shorter than the *Siderial Year*, and consists of 365 Days, 5 Hours, 48 Minutes, 57 Seconds.

The *Lunar Year* is either *Wandering* or *Fixed*.

The

The *Wandering lunar Year* consists of 12 lunar synodical Months; which wants 11 Days of the solar Year. This Year is used by the *Turks* and other *Mahometans*; so that the Beginning of their Year is perpetually shifting thro' the several Seasons, and it revolves in 32 Years.

The *Fixed lunar* or *Lunæ-solar Year* consists sometimes of 12 synodical Months, sometimes of 13; as will be shewn afterwards.

The *Civil Year* is either *Julian* or *Gregorian*.

The *Julian* is so called from *Julius Cæsar*, by whom it was fixed 40 Years before Christ. It consists of 365 Days; only every fourth Year, which is called *Bissextile*, or *Leap-Year*, consists of 366. The additional Day is now put to the End of *February*, so that *February* has that Year 29 Days: But in the ancient *Roman Calendar* the sixth of the Calends of *March*, answering to our 24th of *February*, was that Year reckoned twice over; from whence is the Name *Bissextile*.

The *Gregorian Year* is so called from Pope *Gregory XIII.* by whose Order the Calendar was reformed A. D. 1582. It begins at present 11 Days before the *Julian*. Every centesimal or hundredth Year from

S

the

130 *The Divisions of Time. Part III.*
the Birth of Christ, as 1500, 1600, 1700,
&c. is Leap Year, according to the *Julian*
Account; but according to the *Gregorian*,
it is always a common Year, except when
the Number of Centuries can be divid-
ed by 4 without a Remainder, for then it
is Leap Year. Thus the Years 1600 and
2000 are Leap Years; but the interme-
diate centesimal Years are common ones.
So that the Gregorian Year, or *New Style*,
which is now generally used, gets before
the Julian, or *Old Style*, 3 Days in
400 Years.

* *To know if it be Leap Year.*

Leap Year is given, when four will divide
The Cent'ries compleat, or odd Years be-
side.

EXAMPLE for 1752.

$52 \div 4 = 13$ rem. 0, Leap Year.

$4 \overline{)52} \begin{smallmatrix} 0 \\ 13 \end{smallmatrix}$ Leap Year.

EXAMPLE for 1800

$18 \div 4 = 4$ rem. 2, not Leap Year.

$4 \overline{)18} \begin{smallmatrix} 2 \\ 4 \end{smallmatrix}$ not Leap Year.

C H A P.

C H A P. II.

Of CALENDARS.

THE Calendar (in Arabic *Al-Ma-nach*, from whence is the English word *Almanack*) is a Table, in which all the Days of the Year are set down successively; with *Holy-Days*, both *ecclesiastical* and *civil*, *Terms*, &c. marked in their proper Places. This Table of Days is divided into 52 Weeks, of 7 Days each, and 1 Day over, by Means of the first Seven Letters of the Alphabet A, B, C, D, E, F, G, perpetually recurring throughout the Year. A stands against the 1st of *January*. B against the 2^d, and so on to *December* the 31st, which has A joined to it. The Letter which stands against all the *Sundays* of the Year, is called the *Dominical* or *Sunday Letter* for that Year. If *January* the 1st be *Sunday*, A is the *Dominical Letter*, which stands against every *Sunday* throughout the Year, except it be Leap Year; for then the *Dominical Letter* changes at the End of *February*, moving a Letter backwards: so that G will be the *Sunday Letter* during

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the Remainder of the Year; for the Dominical Letter always shifts backwards, as from A to G, from G to F, and from F to E. If E be the Dominical Letter this Year, D will be the next.

** To find the Dominical Letter for any Year.*

Divide the Cent'ries by 4; and twice what does remain

Take from 6; and then add to the Number you gain

The odd Years and their 4th; which dividing by Seven,

What is left take from 7, and the Letter is given.

EXAMPLE *for* 1752.

$$17 \div 4 \text{ remains } 1$$

$$1 \times 2 = 2$$

$$6 - 2 = 4$$

$$4 + 52 + 13 = 69$$

$$69 \div 7 \text{ remains } 6$$

$$7 - 6 = 1 = A, \text{ the Dominical Letter.}$$

$$\begin{array}{r} 4 \overline{) 17} \text{ (1} \\ \underline{4} \end{array}$$

$$2$$

$$2$$

$$6$$

$$4$$

$$5^2$$

$$13$$

$$7$$

$$\begin{array}{r} 7 \overline{) 69} \text{ (6} \\ \underline{49} \end{array}$$

$$9$$

$$1 = A.$$

** Every common Year brings the Dominical Letter one backward, and every Leap Year two; therefore to any Number of Years, under 100, add its 4th part for the Leap Years, omitting Fractions; and the Sum will be the Number of Times the Letter has shifted backward during that Number of Years, which being divided by 7, the Remainder will be the Number of the Letter of the present Year, reckoning from the Letter belonging to the*

By the Dominical Letter, you may compute on what Day of the Week any Day of the Month will fall throughout the Year, by the following Canon.

At

the last centesimal Year in a retrograde Order; or the Complement of the Remainder to 7 will be the present Dominical Letter in a direct Order, as will appear by the following Example.

Let the Letter of the last centesimal Year be G, and suppose the given Year to be 77.

$$77 \div 4 = 19$$

$$77 + 19 = 96$$

$$96 \div 7, \text{ remains } 5$$

$$7 - 5 = 2$$

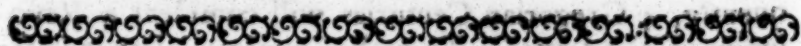
5 backward from G = B.

2 forward from G = B.

When the centesimal Year, which is the last of the Century, is *common*, that Century will bring the Dominical Letter two forward; (100 Years + 24 Leap Years = 124; $124 \div 7$ Remains 5; $7 - 5 = 2$) But when the last Year is *Leap Year*, that Century will bring the Dominical Letter but one forward (100 Years + 25 Leap Years = 125; $125 \div 7$, Remains 6; $7 - 6 = 1$) Consequently, 4 Gregorian Centuries will compleat a Revolution of the Letter: Thus the Dominical Letter is for the Year 1600 A; 1700 C; 1800 E; 1900 G; 2000 A; &c. Now as A, the sixth Letter backward from G, is the Dominical Letter of a *Bissextile* centesimal Year, (which is when the Number of Centuries is divisible by 4 without any Remainder.) The Rule to find it until the next hundredth Year will be, To divide the odd Years, their 4th Part, and 6, by 7; and the Remainder subtracted from 7, will give the Number of the Letter, reckoning A 1, B 2, &c. But as the first common Century brings it two Letters forward from A, or two less backward from G, the Remainder, after dividing the Centuries by 4, must be doubled; then $6 - 2 = 4$, therefore 4 must be added to the odd Years and their 4th in order to find the Dominical Letter 'till the last Year of the second *common* Century; and, for the same Reason, 2 must be added in the next Century, and 0 in the fourth.

¹ ² ³ ⁴ ⁵ ⁶
 At Dover Dwells George Brown Esquire,
⁷ ⁸ ⁹ ¹⁰ ¹¹ ¹²
 Good Christopher Finch, And David Frier.

Where the 12 Words answer to the 12 Months; the first Letter of each Word stands in the Calendar against the first Day of the corresponding Month, as A against *January* the 1st, D against *February* the 1st, &c. Suppose B is the Dominical Letter, I would know on what Day of the Week *June* the 24th falls that Year. E stands against *June* the 1st, *per Canon*. Remember that the 1st, 8th, 15th, 22^d, 29th, is the same Day of the Week in each Month. Now if B be *Sunday*, E is *Wednesday*; therefore *June* the 22^d is *Wednesday*, and the 24th is *Friday*.



C H A P. III.

Of CYCLES.

CYCLES, or Periods, are such Spaces of Time as revolve into themselves again; of which Sort the most considerable are,

The Cycle { of the Sun,
 of the Moon,
 of the Roman Indiction.

1. The

1. The Cycle of the Sun consists of 28 Years, which contain all the possible Combinations of the Dominical Letters, in respect to their successive Order, as pointing out common Years and Leap Years: so that after the Expiration of the Cycle, the Days of the Month return in the same Order to the same Days of the Week, throughout the next Cycle. Except that upon every centesimal Year, which is not a Leap Year, the Letters must all be removed one Place forward, to make them answer to the Years of the Cycle. For Instance, If the Year 1800 were a *Leap Year*, as every centesimal Year is in the Julian Account, the Dominical Letters would be E D, and C would be the Dominical Letter of the next Year; but as it is a *common Year* in the Gregorian Account, D is the Dominical Letter of 1801, which answers to the 18th of the Cycle; C to the 19th &c. until the next centesimal Year.

The Dominical Letter of each Year, in this Cycle, until the Year 1800, appears in the following Table.

1	DC	6	D	11	E	16	F	21	GF	26	G
2	B	7	C	12	D	17	ED	22	E	27	F
3	A	8	B	13	CB	18	C	23	D	28	E
4	G	9	AG	14	A	19	B	24	C		
5	FE	10	F	15	G	20	A	25	BA		

2. The

2. The Cycle of the Moon is a Period of 19 Years, after which the new and full Moons return on the same Days of the Months; only 1 Hour 28 Minutes sooner: So that on whatever Days the new and full Moons fall this Year, they will happen 19 Years hence on the same Days of the Months. Except when a centesimal *common* Year falls within the Cycle, that will remove the new and full Moons a Day later in the Calendar, than otherwise they would have fallen; so that a new Moon which fell, before the centesimal Year, suppose on March 10th, will fall 19 Years afterwards on March 11th.

The Number of the Years in this Cycle is called the *Prime*, from its use in pointing out the first Day of the Moon (*Primum Lunæ*) and the *Golden Number*, as deserving to be writ in Letters of Gold.

The *Golden Numbers* are those placed in the first Column of the Calendar, betwixt *March 21* and *April 18th*, both inclusive, to denote the Days upon which those full Moons fall, which happen upon or next after *March 21st* in those Years, of which they are respectively the *Golden Numbers*. The Day of such full Moon, or the Number of Days from *March 1st* to that Day inclusive, is called the *Paschal Limit*, the next Sunday after which is
Easter

Easter Day. From whence it appears that Easter can never fall sooner than *March 22^d*, nor later than *April 25th*; because those two Days are the earliest and latest *Sundays* that can possibly fall *next after the first full Moon on or after the 21st of March.* These Numbers so placed will mark the Day of the *Paschal Limit* 'till the Year 1900, when they will need some Alteration, as may be seen in *The Earl of Macclesfield's Remarks upon the Solar and the Lunar Years, in Philos. Transactions N^o. 495.*

3. The Cycle of the *Roman Indiction* is a Period of 15 Years, which was used by the ancient *Romans*, but for what Purpose is not now known. It is however used by the Popes, who date their Acts by the Years of the *Indiction.*

The Golden Number, Cycle of the Sun, and Indiction are found for any Year by this Canon.

When 1, 9, 3, to the Year have added been,
Divide by *Nineteen, Twenty-eight, Fifteen:*
By what remains each Cycle's Year is seen †.

T

EXAMPLE

EXAMPLE for 1752.

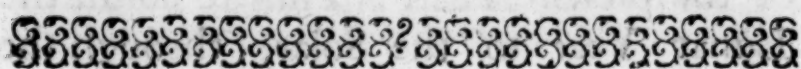
$$\begin{array}{r} 1752 \\ \underline{1} \\ 19)1753(92 \\ 43 \\ 5 = G. N^{\circ}. \end{array}$$

$$\begin{array}{r} 1752 \\ \underline{9} \\ 28)1761(62 \\ 81 \\ 25 = Cy. S. \end{array}$$

$$\begin{array}{r} 1752 \\ \underline{3} \\ 15)1755(116 \\ 25 \\ 105 \\ 15 = R. Indic. \end{array}$$

These three Cycles, multiplied into one another; that is, $28 \times 19 \times 15$, amount to 7980, which is called the *Julian Period*, after which the three foregoing Cycles will begin again together. This Period had its imaginary Beginning 710 Years before the Creation, and is not yet complete. It is much used in Chronological Tables.

† The Reason of adding these Numbers, *viz.* 1 for the *Golden Number*, 9 for the *Cycle of the Sun*, and 3 for the *Indiction*, to the Date of the Christian *Æra*, is because so many Years of the respective Cycles were elapsed when the Christian *Æra* began. If then you divide the current Year of Christ, with the Addition of the respective Number, by the whole Number of the Cycle, the Quotient shews how many compleat Cycles have run out, since the Beginning of that in which the Christian *Æra* commenced, and the Remainder, if any, shews the present Year of the Cycle; if there be no Remainder it is the last Year, which compleats the Cycle.



C H A P. IV.

Of the EPACT.

THE Epact is a Number arising from the Excess of the Solar Year above the Lunar, of 12 synodical Months, which Excess is 11 Days; or the Epact of any Year expresses the Number of Days from the last new Moon of the old Year, (which was the beginning of the present Lunar Year) to the 1st of *January*. The first Year of the Cycle of the Moon the Epact is 0, because the Lunar Year begins with the Solar. On the second, the Lunar Year has begun 11 Days before the Solar Year, therefore the Epact is 11. On the third it has begun twice 11 Days before the Solar Year, therefore the Epact is 22. On the fourth it begins three times 11 Days sooner than the Solar Year; the Epact would therefore be 33, but 30, being an intire Synodical Month, must that Year be intercalated; or that Year must be reckoned to consist of 13 Synodical Months, and there remains 3, which is the true Epact of the Year; and so on to the End of the Cycle, adding 11 to the Epact of the last Year, and always rejecting 30, gives the Epact

T 2 of

of the present Year. Thus to adjust the Lunar Year to the Solar, through the whole Cycle of 19 Years, 12 of them must consist of 12 Synodical Months each, and 7 of 13, by adding a Month of 30 Days to every Year when the Epoch would exceed 30, and a Month of 29 Days to the last Year of the Cycle, which make in all 209 Days *i. e.* 19×11 so that the *Intercalary* or *Embolimæan* Years in this Cycle are 4, 7, 10, 12, 15, 18, 19.

* *A general Rule to find the Gregorian Epoch.*

Let the Cent'ries by 4 be divided, and then
What remains multiply'd by the Number 17;

Forty three times the Quotient, and 86
more

Add to that; and dividing by 5 and a
Score; From

*† If the new Moons returned exactly at the same time after the Expiration of 19 Years, as the Council of Nice supposed they would do (when they fixed the Rule for the Observation of Easter, and marked the Days of the new Moons in the Calendar for each Year of the Lunar Cycle) then the Prime multiplied by 11 would always give the Epoch: But in a Julian Century the new Moons anticipate, or happen earlier than that Council imagined they would, by $\frac{8}{25}$ of a Day. In a Gregorian *Common Century*, which is one Day shorter than a Julian Century, they happen $\frac{17}{25}$ of a Day later ($1 \text{ Day} - \frac{8}{25} = \frac{17}{25}$) Now $\frac{17}{25} \times 3 = \frac{51}{25}$ for the three *common* Centuries; but $\frac{8}{25}$ being subtracted on account of the Gregorian

Ch. 4. *The* EPACT. 141

From 11 times the Prime, subtract the
last Quote, And
And rejecting the Thirties, gives th' E-
pact you sought †.

EXAMPLE for 1752.

$ \begin{array}{l} 17 \div 4 = 4 \text{ remains } 1 \\ 1 \times 17 = 17 \\ 43 \times 4 + 86 + 17 = 275 \\ 275 \div 25 = 11 \\ 11 \times 5 \text{ (G. No.)} = 55 \\ 55 - 11 = 44 \\ 44 - 30 = 14 = \text{Epact.} \end{array} $	$ \begin{array}{r} 4 \overline{)17(1} \\ \underline{4} \\ 17 \\ \underline{43} \\ 172 \\ \underline{86} \\ 17 \\ 25 \overline{)275(11} \\ \underline{25} \end{array} $	$ \begin{array}{r} \text{G. N}^\circ. = 5 \\ \underline{11} \\ 55 \\ \underline{11} \\ 30 \overline{)44(1} \\ \underline{30} \\ 14 = \text{Epact.} \end{array} $
---	---	--

* To find the Epact until the Year 1900.

The Prime wanting one multiply'd by 11,
And the Thirties rejected, th' Epact is
given †.

EXAMPLE

rian *Bissexile Century*, there will remain $\frac{4}{5}$. Therefore in 4 Gregorian Centuries the new Moons will happen later by $\frac{4}{5}$ of a Day, and the Epacts must be decreased accordingly. At present the Gregorian Epact is 11 Days short of the Julian Epact; but the Quotient of the Number of the Centuries divided by 4, which at this time is 4, multiplyed (as the Rule directs) by $\frac{4}{5}$, with the Addition of the Remainder 1 multiplyed by $\frac{1}{5}$, makes in all but $\frac{18}{5}$ or 7 Days $+\frac{1}{5}$, therefore $\frac{8}{5}$ i. e. 3 Days $+\frac{1}{5}$ must be added to compleat the 11 Days; and the Rule thus adjusted to the present Time will hold true ever afterward.

*† The Reason of this Rule is, that the last Quotient which is to be subtracted from 11 times the Prime, according to the foregoing general Rule, will always be 11 until the Year 1900. Now $\text{Prime} - 1 \times 11 = \text{Prime} \times 11 - 11$.

EXAMPLE.

$$\begin{array}{r}
 \text{G. N}^\circ. 5 - 1 \times 11 = 44 \\
 44 - 30 = 14 = \text{Epact.}
 \end{array}
 \qquad
 \begin{array}{r}
 \text{G. N}^\circ. = 5 \\
 \frac{1}{4} \\
 \frac{11}{30)44(1} \\
 14 = \text{Epact.}
 \end{array}$$

A Table of the Golden Numbers and their corresponding Epacts until the Year 1900.

G. N.	Epac.	G. N.	Ep.	G. N.	Ep.	G. N.	Ep.				
1	—	0	6	—	25	11	—	20	16	—	15
2	—	11	7	—	6	12	—	1	17	—	26
3	—	22	8	—	17	13	—	12	18	—	7
4	—	3	9	—	28	14	—	23	19	—	18
5	—	14	10	—	9	15	—	4			

Easter may be computed from the Epact by the two following Canons.

** To find Easter Limit, or the Day of the Paschal Full Moon, from March the 1st inclusive.*

Add six to the Epact, reject 3 times 10,
What's left take from 50, the Limit you gain:

Which if 50, one less you must make it, and even

When 49 too, if Prime's more than 11 †.

EXAMPLE

**†* When the Epact is 0, the next full Moon after March the 21st, will happen on April the 13th, to which

EXAMPLE for 1752.

$\begin{aligned} \text{Epact} &= 14 \\ 14 + 6 &= 20 \\ 50 - 20 &= 30 = \text{Limit.} \end{aligned}$	$\begin{aligned} \text{Epact} &= 14 \\ &6 \\ \hline &20 \\ &50 \\ &30 = \text{Limit.} \end{aligned}$
---	--

By the Limit, and Dominical Letter to find Easter Day.

If the Letter and 4 from the Limit you take,
 And What's left from next Number which Sevens will make ;
 Adding then to the Limit what last does remain,
 You the Days from St. David's to Easter obtain †.

EXAMPLE

which add 31 for the Days in March, and the Sum 44 is the Limit. From this Number therefore the Epact is to be subtracted, but only when it is less than 24 ; because the Remainder, or Limit is never to fall short of 21. When the Epact is more than 24, 30 must be added to 44, and it must be subtracted from 74. But when it is 24 it must be taken from 73, since the Limit is never to exceed 49. Likewise when the Epact is 25, it must be subtracted from 73, if the Golden Number be more than 11, according to the Tables and Directions for placing the Golden Numbers, to point out the Days of the Paschal full Moons in the new Calendar. Now 44—Epact=50—Epact+6 therefore add 6 to the Epact and subtract from 50, which is more convenient in working, and the Rule will hold in all Cases.

† The Reason of this Rule is because D stands against March the 1st, which is 4 Letters short of the next A in the

EXAMPLE for 1752.

Limit=30, Dom. Let. A=1	Limit=30	A=1
1+4=5	5	4
30-5=25	25	5
28-25=3	28	=next Sevens.
30+3=33	3	
33-31 Days in March=2	30	=Limit.
April the 2 ^d Easter Day	33	Days.
	31	=March.
	April 2	=Easter Day.

The Age or Change of the Moon may be found, pretty nearly, by the follow-Canon, in which the 12 Numbers answer to the 12 Months, beginning with *January*.

Janus 0, 2, 1, 2, 3, 4, 5, 6,
8, 8, 10, 10, these to the Epact fix,
The Sum, bate 30, to the Month's Day
add,
Or take from 30, Age or Change is had †.

EXAMPLE

the Calendar; therefore if you take 4 from the Limit, and also the Number of the Letters from A to the Dominical Letter of the Year inclusive, you come to a *Sunday*, from whence therefore the Days to *Easter Sunday* consist of Sevens, or intire Weeks; Consequently if you substract what now remains of the Limit, from the next higher Number which is made up of Sevens, the Remainder is the Number of Days from the Paschal full Moon to the next *Sunday* after it: *That* therefore, added to the Limit, gives the whole Number of Days from *March* the 1st to *Easter* inclusive.

† The Reason of adding these Numbers to the *Epact* in the several Months, is because the *Lunar Synodical Months*,

EXAMPLE March 10, 1752.

$ \begin{array}{r} 14 + 1 + 10 = 25 = \text{Moon's Age.} \\ 14 + 1 = 15 \\ 30 - 15 = 15 = \text{Day of the Change} \end{array} $	$ \begin{array}{r} \text{Ep.} = 14 \\ \hline 1 = \text{N}^{\circ} \text{ of the Month.} \\ 15 \\ 10 = \text{Day of the Month.} \\ \hline 25 \text{ Days} = \text{Moon's Age.} \\ 30 \\ 15 \\ \hline 15 \text{ March} = \text{Change.} \end{array} $
--	---

Months fall short of the *Calendar Months*; so that the *Epact*, which expresses how much the Lunar Year falls short of the Solar or Calendar Year, must be considered as continually increasing; and therefore to find the new Moons which are the Beginnings of the *Synodical Months*, an Addition must be made to the *Epact* in every Month, and more and more as the Year advances; which additional Numbers are called the *Menstrual Epacts*. Only nothing is to be added to the *Epact* in *January*, because the *annual Epact*, together with the Day of the Month, does then express the true Age of the Moon: But as *January* has 31 Days, which is near 2 Days more than a *Synodical Month*, therefore the Beginning of the Lunar Month in *February*, will fall near 2 Days sooner than it did in *January*; Consequently 2 is the *Menstrual Epact* of *February*; and then as *February* has but 28 or at most 29 Days, which may be accounted one Day less than a *Synodical Month*, the next Lunar Month will begin one Day later in *March* than it did in *February*; Consequently the *Menstrual Epact* of *March* decreases instead of increasing, and is but 1. If from thence you reckon the Lunar Months to consist of 30 Days and 29 interchangeably, the new Moons will fall so much earlier in the following Months, than the new Moon did in *January*, as is expressed by the *Menstrual Epacts* in the Canon, viz 2 Days in *April*, 3 in *May*, &c. until they amount to 11 Days at the End of the Year, which are then added to the *annual Epact*.

* *To find the Time of the Moon's coming to the South, and of High-Water at London Bridge.*

Four times the Moon's Age, if by 5 you divide,
Gives the Hour of her Southing: Add 2
for the Tide †.

EXAMPLE, Moon's Age=9 Days.

$\begin{array}{l} \text{Moon's Age} = 9 \times 4 = 36 \\ 36 \div 5 = 7 \text{ remains } 1 \\ \text{Southing} = 7 \text{ Hours } 12 \text{ Minutes.} \\ 7 + 2 = 9 \\ \text{High-Water at } 9 \text{ H. } 12 \text{ M. p. m.} \end{array}$	$\begin{array}{r} 9 \\ 4 \\ \hline 5 \overline{)36} (7 \text{ H.} \\ 1 \\ \hline 12 \text{ M.} = \frac{1}{5} \text{ H.} \\ 7 \text{ H. } 12 \text{ M. p. m.} = \text{Southing.} \\ 2 \\ \hline 9 \text{ } 12 = \text{High-Water.} \end{array}$
--	--

*† The Reason of this Rule is, that as the Moon at the Change comes to the South with the Sun, or at 12 o'Clock; and as there are 30 Days, nearly, from one new Moon to another, and 24 Hours in a Day; therefore she loses one Day with another $\frac{2}{3}$ or $\frac{4}{5}$ of an Hour in the Time of her Southing: Now the Moon's Age, or Number of Days from the Change being multiplied by 4, the Product is so many *fifths* of an Hour as she has lost, which divided by 5 is reduced to *Hours*, and the Remainder, if any, multiplied by 12 will be Minutes.

The Reason of adding 2 Hours to the Time of the Moons Southing, for High-Water at London Bridge, is because, though it is High-Water in the open Sea, under the Meridian of London, when the Moon is on that Meridian, yet the Tide takes about 2 Hours more in flowing up to London.



C H



Of EPOCHAS or ÆRAS.

AN Epocha or Æra is a fixed Point of Time, at or near to which some remarkable Event has happened, from whence a Series of Years is computed, as, from the *Creation of the World*, from the *Deluge*, from the *Birth of Christ*, &c.

As the Constitution of Epochas is merely arbitrary, and not founded on any astronomical Considerations, different Nations have made Use of different Epochas, commonly taken from some remarkable Occurrence in their respective Histories. Thus the *Romans* computed their Years from the building of *Rome*. The *Greeks*, from the first Institution of the *Olympic Games*, which were celebrated at the Beginning of every fifth Year. Hence they computed their Years by *Olympiads*, each Olympiad containing four Years. The *Turks* and *Arabians*, and generally all that profess the Mahometan Religion use the Epocha of the *Hegeira*, which is computed from the Time of *Mahomet's* Flight from *Mecca* to *Medina*.

148 Of EPOCHAS, or ÆRAS. Part III.

The ancient *Jews* made Use of various Epochas, taken from remarkable Occurrences in their History, as from their *Exodus* or Departure from *Egypt*, from the Building of *Solomon's Temple*, from the *Assyrian* and *Babylonian Captivities*; &c. The modern *Jews* use, principally, the Epocha of the *Creation*. The Epocha of *Christ*, or *A. D. i. e.* the Year of our Lord commencing from our Saviour's Nativity, is now chiefly used by Christians, at least throughout *Europe*; for the *Abyssinian* Christians are said to use the *Dioclesian Æra* in all their Ecclesiastical Computations; which is otherwise called the *Æra of the Martyrs*, because of the great Number of Christians that suffered Martyrdom in the Reign of the Emperor *Dioclesian*. The vulgar Christian Æra, whose Author was *Dionysius Exiguus*, an Abbot of *Rome* in the sixth Century, is allowed by the best Chronologers to begin four Years too late, or after the true Time of Christ's Birth; Yet long Use has now so established it, that there is less Inconvenience in using it with that Error, than there would be in correcting it. *Dionysius* dated his Æra from the Conception of Christ, which he supposed to be on *March 25*, which Method obtained in *England* until the Year 1752. But now the first of *January* is reckoned the Beginning of the Year

Ch. 5. Of EPOCHAS, or ÆRAS. 149

Year in all the *British* Dominions, as well as by most other Nations of Europe.

Besides these great Epochas, as we may call them, it has been usual to compute by lesser Epochas, commencing with the Beginning of the Reign of Emperors and Kings, and expiring at their Death. Thus the ancient *Romans* reckoned by the Years of the Reign of their Emperors; and thus in *England* the *Anno Regni*, which is computed from the Beginning of the King's Reign, is generally used in Acts of Parliament, and Law Instruments.



A TA-

A TABLE of some of the more considerable Epochas which are used in sacred and profane History, reduced to the Years of the Christian Æra, and the Julian Period,

	Years before Christ.	Julian Period.
The Creation of the World	4004	711
The Deluge — — —	2348	2367
The <i>Exodus</i> — — —	1498	3216
Founding of <i>Solomon's</i> Temple	1018	3697
First Olympiad — — —	776	3938
U. C. or building of <i>Rome</i>	753	3961
<i>Æra</i> of <i>Nabonassar</i> , much used by Astronomers }	747	3967
The <i>Assyrian</i> Captivity of <i>Israel</i>	724	3990
The <i>Babylonian</i> Captivity of <i>Judah</i> — — — }	601	4113
Death of <i>Alexander</i> the Great	324	4390
Birth of Christ, or Christian <i>Æra</i> — — — }	A.D. 47	4714
Destruction of <i>Jerusalem</i>	69	4783
<i>Æra</i> of <i>Dioclesian</i> , or of the Martyrs — — — }	284	4997
<i>Hegeira</i> of the Mahometans	622	5335
Beginning of the Reformation	1517	6230
Accession of King <i>George II.</i>	1727	6440

A N





APPENDIX,

Attempting to explain the Account
of the first and fourth Day's
Work of Creation, in the first
Chapter of *Genesis*.



THE Difficulties with which
the Mosaic Account of the
Creation seems to be pressed
are chiefly these two:

FIRST, That the Earth is said to be
enlightened, and the Succession of Day
and Night settled the first Day; and yet the
Sun (whose Light makes Day to the Earth)
not created until the fourth Day.

U

SECONDLY,

SECONDLY, That God should take five Days in making this Earth and its Furniture, and yet but one Day, *viz.* the fourth, in creating the Sun, Moon, and Stars, (in Comparison with all which, this Earth is but a mere Point or Atom) may seem very unlikely; for tho' it be not impossible to Divine Power, it seems hardly reconcileable to Divine Wisdom: and this Account of the Creation appears strangely irregular, and the several Parts of it out of all Measure disproportionate to one another.

In order to solve these Difficulties, let it be observed,

1. That the Mosaic Account of the Creation does not seem to be designed for an Account of the whole Creation of God; for there is no mention of the Creation of Angels in it *: and besides, the first Verse, *In the Beginning God created the Heaven*

* If by the *Morning Stars which sang together, when God laid the Foundations of the Earth*, Job xxxviii. 4, 7. we are to understand Angels, according to the common received Opinion, which seems very probable, from their being called the Sons of God in the Words that follow, *and all the Sons of God shouted for Joy*; that Text gives a plain Intimation that Angels were in being at the very Beginning of the Creation of this World; or *when God laid the Foundations of the Earth*; and therefore that they were created before it. And does not the Allusion in that Text, *viz.* the Angels being called, or compared to Stars, at that Time, seem further to intimate, that there were Stars also then in Being, and consequently that there were Stars created before this World; or, however, before the fourth Day?

and

and the Earth, which may be considered as the Title, or general Contents of the whole following Account, does expressly limit it to the mundane Creation, even the *Heaven* and the *Earth*. And by the *Heaven*, in this Chapter, is meant nothing but the *Firmament*, or Air, which supports the Clouds, as appears from Verses 7, and 8, *God made the firmament, and divided the waters which were under the firmament from the Waters which were above the firmament, and he called the firmament HEAVEN.* The Mosaic Account of the Creation seems plainly therefore to be a designed Account of the Creation of this Planet only, *viz.* the Earth and its Atmosphere, with its various Furniture; the Sun, and many, at least, of the Stars being, it may be, created before. Tho' it is not unlikely that the Moon, being a constant Attendant on the Earth, and designed, in a good Measure, for the Use of it, was created at the same Time; and perhaps we shall find some Reference to her Motion in this Account afterward.

2. If there be any considerable Parts of the Work of the Creation of this World, which are not taken Notice of in any of the other Days, and which will fully answer the Phænomena of the first and fourth Day's Works, it is highly probable

those are the very Works there intended and referred to.

Now it is certain, that God's giving the Earth its diurnal Motion on its own Axis, and its annual Motion in its Orbit round the Sun, (to which we may also add his giving the Moon her Motion round the Earth) were very considerable Parts of the Work of the Creation of this World, and to which no Reference can be supposed in the Account of any of the Six Days Work, unless in the first and fourth.

Let us then suppose that the first Day's Work which *Moses* describes, was God's giving the Earth its diurnal Motion; and let us enquire how that will answer the Phænomena related in Verses 2, 3, 4, 5.

Verse 2. *And the earth was without form and void, and darkness was upon the face of the deep, and the Spirit of God moved upon the face of the waters.*

Ver. 3. *And God said, Let there be light: and there was light.*

Ver. 4. *And God saw the light that it was good: and God divided the light from the darkness.*

Ver. 5. *And God called the light Day, and the darkness he called Night: and the evening and the morning were the first day.*

The Particulars of this Account are,

1. That the earth was without form and void, i. e. a mixed and confused Mass of Solids

Solids and Fluids, of Earth and Water, without any such *form* of Land and Sea, Continents, Islands, &c. as it afterwards received. And *void*, or destitute, of all the Furniture of Trees and Plants, as well as of animal Inhabitants.

2. *And darkness was upon the face of the deep.* The Hebrew Word (תהום) *Deep* is elsewhere applied to the very Bottom of the Sea, which is most remote from the upper Surface, and out of Sight; as *Job* xxviii. 14. *Exod.* xv. 5. *Isaiab* lxiii. 13. Suppose it should mean here the lower Hemisphere of the Globe, which was remote from the Sun; (for it seems natural to speak of that Hemisphere which was towards the Sun, and enlighten'd by his Rays, as the Top, or upper Part; and of the other, as the Bottom, or lower Part:) Then the Meaning would be, that the lower Hemisphere as was yet all dark, having no Light from the Sun, as the upper had.

Or, rather, if Mr. *Whiston's* Hypothesis may be admitted, that *the ancient Chaos, and Origin of our Earth, was the Atmosphere of a Comet.* (*vide New Theory of the Earth, page 73. fourth Edition.*) Or, as that most penetrating Philosopher Dr. *Halley* seems to suspect, *that it might be a former World, reduced to a Chaos by the Choc of a Comet* (*vide Philos. Transf. N^o 383. or Mr. Eames's Abridgment, Vol.*

Vol. VI. Part II. Page 4.) If, I say, it may be admitted, according to either of these Hypotheses, or any other, that the Chaos had been created, and was in being, some considerable Time before the Six Days Work begun, by which it was formed into a habitable World ; we may then understand the Word (תהום) *Deep*, in this Text, in the more common scriptural Sense of it, *viz.* as signifying a great Sea of Water, or vast fluid Body. For supposing the Chaos to be a thick muddy Fluid, consisting of Earth and Water mixed together, and supposing it had no diurnal Motion before the Six Days Work begun ; one Hemisphere would probably be, in a good Measure, dried and crufted by the Heat of the Sun continually shining on it ; while the other, which was constantly in Darkness, and destitute both of the Light and Heat of the Sun, would be all fluid, or a vast muddy Sea. And this is what, perhaps, we are to understand by the *Deep* and the *Waters* in this Text.

3. *And the Spirit of God moved upon the face of the Waters.* The Hebrew Word (מרחפת) *moved*, is said, by most Expositors, to refer to Incubation ; or to a Hen's sitting upon, and hatching her Eggs, and brooding her Young. But this seems to be said, without sufficient Reason ; for the same Word is used but in two other Places in all the

the

the Bible, and there does not appear to be any Reference to Incubation in either of them. One is *Jerem. xxiii. 9.* where it is rendered in the English *shake*, and fitly enough, as appears by the Context, *My heart is broken within me, all my bones shake.* The other is *Deut. xxxii. 11.* where it is rendered to *flutter.* *As an eagle stirreth up her nest, fluttereth over her young, spreadeth abroad her wings, taketh them, beareth them on her wings.* But neither is there any Reference, in that Place, to Incubation, or Brooding. For the young Eagles are there supposed to be already hatched and sufficiently brooded, so as to be fit to fly abroad. The Parent Eagle is now teaching them to fly; in order to which, after she has stirred them up, or awakened them, she flies backward and forward over the Nest, in their Sight, in order to induce them to imitate her; and when she has at length prevailed with them to spring up into the Air, she bares them up with her Wings, when they are in Danger of falling. So Eagles are said to do when they are teaching their young ones to fly*. So that this Word imports no more than to *move*, or, at most, to *move swiftly.* The Sense then may very well be, that the Spirit of God moved the

* Vid. *Nature Displayed*, Vol. I. Part II. Page 63.

Surface of the Globe, and thereby gave it its diurnal Motion *.

Mr. *Whiston* says, in his *New Theory of the Earth*, Page 111, “ Dr. *Halley* and “ myself do find, from the Phænomena “ of the Variation and Inclination of Needles, that the external Parts of the Earth “ received the original Impulse which caused “ the diurnal motion, and that it was from “ them conveyed to the internal Parts.” If so, *the Spirit of God moving upon the face of the waters*, or making the Surface to move, is a very just and philosophical Account of God’s giving the Earth its diurnal Motion.

4. *And God said let there be light: and there was light.* *God said*, is a sort of poetical Phrase, intimating how suddenly, and with what Ease, this Motion was communicated to so great a Body by the Divine Power; like *Psalms xxxiii. 19.* *He spake and it was done, he commanded and it stood fast.* Thus God willed that the whole

* מרחפת from רחפ commoveri. Part. Præs. Pihel. Verba quæ in Kal sunt neutra in Pihel activa sunt, ut למד didicit למד discere fecit, docuit, *Buxtorf. Thes.* Therefore מרחפת signifies *made to move, or put in Motion.* Then the exact English of רוח אלהים מרחפת על פני המים is, *the Spirit of God made the Face, or Surface, of the Waters to move, or communicated Motion to it, according to the Use of the Particle על, Gen. xxxviii. 12. Judg. ix. 49. 1 Sam. i. 10, &c.*

Globe should be enlightened; and no sooner was it *willed*, but it was *effected*, by the Spirit of God's moving upon the Face of the Waters, or making the Surface of the Globe to move; and Day-light was hereby distributed successively to all Parts of the World.

5. *And God saw the light, that it was good: and God divided the light from the darknes. And God called the light Day, and the darknes he called Night: and the Evening and the Morning were the first Day.* Thus was God's Will of enlightening the Earth completely executed; and hereupon Light and Darknes were equally divided to the whole Globe, and the regular Succession of Day and Night was settled and established. Mr. *Whiston* indeed supposes, in his *New Theory of the Earth*, p. 85. that the Earth's diurnal Rotation did not commence till after the Fall of Man. But may not the present Shape of the Earth be objected to that Hypothesis? *viz.* That it is an oblate Sphæroide, having its Diameter at the Equator above thirty Miles longer than its Axis; which has undoubtedly been occasioned by its diurnal Rotation. For the same Mr. *Whiston* observes in his *Astro. Prin. of Religion*, p. 32. that
 “ all Globes, which have no diurnal Re-
 “ volutions about their own Axes, must,
 “ by the Equality of the Weight of Bo-
 X “ dies

“ dies in all their Regions, be perfect
“ Spheres; and all the Parts of their Sur-
“ face must, generally speaking, be at the
“ same Distance from the Center. But
“ all Globes that have such a diurnal Ro-
“ tation, (which will necessarily be swiftest
“ at the Equator, and, by Consequence,
“ will cause the Parts to recede from the
“ Axis of Motion, chiefly near the Equa-
“ tor) will be oblate Sphæroides, or higher
“ in the Equatorial, and lower in the Po-
“ lar Regions.”

Now if the Earth were at first a perfect Sphere, and the diurnal Rotation were given to it after it was finished, then either

1. Such an Alteration of the Shape of the whole Globe, after it was finished (as the diurnal Rotation is supposed to occasion) must bring a prodigious Confusion upon the whole Surface, and throw it into a sort of Chaos again. Or,

2. If only the fluid Parts, or the Water, would yield to the centrifugal Force, and be thereby thrown into an oblate sphæroidical Form, but not the solid Parts, or Land; then the Waters, by their being raised so much higher than the Land near the Equator, would overflow the Land, and bring a lasting Deluge on those Parts of the Earth: and, on the other Hand, the Waters

ters would be sunk in the Polar Regions many Miles below the Land.

Is it not therefore more probable, that the Globe received its diurnal Motion on the first Day of the Creation; while the Earth and Water continued in one mixed Mass, and before they were separated from each other?

And is it not also probable, that God's giving the Earth its diurnal Motion was the very Work, described by *Moses*, of the first Day?

If it should be objected, that, according to this Hypothesis, it might as well have been said, *God said let there be darkness, as let there be light*; since, by the diurnal Rotation, Darkness and Light were equally divided throughout the whole Globe. It may be replied,

1. That *Light* and the *Day*, being so much more pleasant and useful than *Darkness*, and the *Night*, (tho' that also has its great Use,) it was more natural to speak of the Light, as being now diffused over the whole Globe, than of Darkness. And it is a more beautiful and elegant Account of this Day's Work, to describe it by the Production of Light, than of Darkness; tho' both of them were now made to succeed in their Turns to one another.

2. It is most natural to understand the Word *Light*, ver. 3. (*God said let there*

be light) in just the same Extent as the Word *Darkness* in the Verse before, to which it is opposed. (*Darkness was upon the face of the deep.*) Now if the *Deep*, the Face of which was in *Darkness*, means only one Hemisphere, then the new Production of *Light* must be understood in Reference only to one and the same Hemisphere. And it is observable, that the Scene of that Action, by which we suppose the new Light was produced, is represented to be *the face of the waters*, meaning, probably, the same as the *Deep* or the dark fluid Hemisphere; not but that the Force which gave the Globe its Rotation might be communicated to the whole Surface: but as the *Waters*, or the *Deep* only was destitute of Light before, and upon that Hemisphere only was new Light now produced, *that* is with peculiar Propriety mentioned as the Scene of this Action. As for the *Earth*, or drier Hemisphere, tho' it *was without form and void*, yet it enjoyed the Light of the Sun before; but *darkness was upon the face of the deep*, therefore *the Spirit of God moved upon the face of the waters*; upon which that Hemisphere was enlightened, as well as the other, and Day and Night were equally divided to all Parts of the Globe.

Let

Let us again suppose, that the Fourth Day's Work was God's giving the Earth its annual Motion round the Sun, and the Moon its Motion round the Earth; and let us see how these two Motions will answer the Phænomena described in Verses 14, 15, 16, 17, 18, 19.

Ver. 14. *And God said, Let there be lights in the firmament of the heaven, to divide the day from the night; and let them be for signs, and for seasons, and for days, and years.*

Ver. 15. *And let them be for lights in the firmament of the heaven, to give light upon the earth.*

Ver. 16. *And God made two great lights; the greater light to rule the day, and the lesser light to rule the night: he made the stars also.*

Ver. 17. *And God set them in the firmament of the heaven, to give light upon the earth.*

Ver. 18. *And to rule over the day, and over the night, and to divide the light from the darkness: and God saw that it was good.*

Ver. 19. *And the evening and the morning were the fourth day.*

The Particulars in this Account are as follow:

Let there be lights in the firmament of the heaven, to divide, &c. or, (as the Hebrew

brew

brew יהי מארת ברקיע השמים להבדיל may as well be rendered) *let the lights in the firmament of the heaven be to divide, &c.* importing not their first being created on that Day, but their being made to serve new Purposes; to which they were now applied and adapted, by Means of the Earth's and Moon's Motions in their respective Orbits. As

1. *To divide the day from the night,* which indeed had been effected by the former Motion that was given to the Earth on the first Day. But as now the Sun and the Moon were made to serve all their designed Uses and Purposes to the Earth, it was no inelegant Repetition to recite them here all together, this, as well as the others. They were now made, not only to divide the Day from the Night, but also

2. *To be for signs, and for seasons, and for days, and years.*

(1.) *For Signs*, such as the Changes and various Phases of the Moon, and the solar and lunar Eclipses; which are so many sensible Signs, or Indications, to Men of the Divine Wisdom, Power, and Goodness. Thus the *heavens declare the glory of God; and the firmament sheweth his handy-work.* Psal. xix. 1. Or, *for marks of distinction*, (as the Hebrew Word אות signifies, Gen. iv. 15. *God set a mark upon Cain*) i. e. betwixt one Part and Portion of Time and another;

another; to which Purposes the Changes of the Moon, the Equinoxes, Solstices, &c. are greatly useful.

(2.) *For Seasons*, to produce a Change and Variety of Seasons; as Spring, Summer, Autumn, and Winter.

(3.) *For Days*, either to make a Difference in the Length of Days; or to distinguish remarkable Days, for solemn Festivals, (such as the first Day of the Year, and the first Day of the lunar Month, which were observed by the Jews;) and for many other Conveniencies in civil Life to all Nations.

(4.) *And Years*, viz. to measure Time by Years, and Cycles of Years, which is of vast Use to Men in the Computation of Time, and in keeping Records of human Affairs.

All which Uses of the Sun and Moon to the Earth, depend upon and result from the Motions of the Earth and Moon in their respective Orbits.

3. *To be for lights in the firmament of the heaven, to give light upon the earth. In the firmament, viz.* as their apparent Place; for tho' our Reason informs us of the remoter Distances of the Heavenly Bodies; yet, to our Eyes, (which are not able to distinguish any Difference in the Distance of visible Objects, beyond the Limits of a few Miles,) they all appear as
if

if they were really in the Firmament, or Earth's Atmosphere; which is therefore the proper Place to represent them in, as they are seen from the Earth.

Both the Sun and the Moon were now made *to be for lights, to give light upon the earth*; which it is very possible the Moon might not do before, being placed, perhaps, in Conjunction with the Sun till the fourth Day. Nor did the Sun before enlighten the Earth in the same Manner as now, when the Earth had received its new Motion. Or, perhaps, this 15th Verse is only a Repetition, like Verses 17th and 18th, which see below.

4. *And God made two great lights, the greater light to rule the day, &c.* Ver. 16. The Hebrew Word for *made* in this Text is not (ברא) *Bara*, as in Ver. 1. which more generally signifies to create, or bring into Being; generally, I say, for even this Word *Bara* is sometimes applied to extraordinary Divine Operations, in which there is yet no new Creation, or Production of any new Being. Thus it is used concerning God's *making* the Earth to open and swallow up *Korah* and his Company. *Numb.* xvi. 30. See also *Exod.* xxiv. 10. *Isa.* xlv. 7, 8. *Psal.* li. 10. Therefore there is no absolute Necessity of taking the first Production of the Chaos, into the Account which *Moses* gives, in this Chapter,

ter, of the Creation of the World : That might have been in being long before any Part of the Work which is here described was begun. Or, if the first Verse should refer to the Production of the Chaos, yet I can see no manner of Necessity of understanding Ver. 16. of a new and proper Creation of the heavenly Lights; for here the Word for *made* is עָשָׂה *basab*, a Word of very general Meaning, which is usually applied to any Sort of Operation and Action; and, particularly, it signifies to *constitute, order, or appoint*, as God (*basab*) *made Moses and Aaron*, when he appointed them to their respective Offices in the State and Church of *Israel*, 1 Sam. xii. 6. The same Word is applied to the making Men Priests, 1 Kings xii. 31. 2 Chron. xiii. 9. The Meaning of it seems to be distinguished from *creating*, Gen. ii. 3. *God rested from all his works which he had created and made*; which, perhaps, may be thus understood : Which he had not only brought into Being, but disposed them into Order. Thus, on the fourth Day, God *made* the two great Lights, (which we suppose to have been created before,) as he now made them to serve new and different Purposes from what they had done before; just as the Princes of *Israel* are said to have *made the house of Jonathan the prison*, or *they made it for a prison-house*,

(אתו עשו לבית הכלא) *Jer. xxxvii. 15.* when they converted it to that Use. So here, *God made the two great Lights*; that is, he made them to rule, even the greater of them, viz. the Sun, to rule the day, by lengthening some Days, shortening others, and by dispensing a greater Quantity of Light and Heat to some Days than to others. *And the lesser light, viz. the Moon, to rule the night*, by making some Nights light, and leaving others dark; enlightening only Part of some Nights, sometimes the former Part, and sometimes the latter.

As for *the Stars*, mentioned at the End of Ver. 16. let it be observed, that the Words *he made*, which are immediately prefixed to *the Stars*, in our Translation, are not in the Original. (Which, indeed, our Translators have intimated, by printing them in a different Character.) Suppose then we connect *the stars* with *night*, the Sense will be, *he made the lesser light to rule the night and the stars* *. Thus while the Moon is performing her periodical Course, and seems to traverse among the Stars, she veils from our View, sometimes one Parcel of Stars, sometimes another, by

* לממשלת הלילה ואת הנוכחיים *ad dominium noctis et stellarum*. Thus אר is the Sign of the Genitive Case, *Numb. x. 2.* את המחנות *ad professionem Castrorum*, *Numb. xxiii. 10.* מספר אר *numerum quartæ partis* Israel.

her Body and her Light, to a considerable Distance from her ; which, perhaps, may be intended here by her *ruling the stars*.

Or if we should follow the more common Versions, and connect *the Stars* which *God made*, in the Beginning of the Verse ; the Meaning may then be, that, by giving the Earth its new Motion, on this fourth Day, *he made the stars also*; as well as the Moon, *to rule the night* : Which Sense is rendered very probable, by comparing *Psal. cxxxvi. 7, 8, 9. To him that made great lights——the sun to rule the day——the moon and stars to rule by night*. And now the Stars were made to rule the Night in another Manner than they would have done if the Earth had only had its diurnal Motion ; for then the same Hemisphere of Stars must always have appeared (in a clear Sky) at the same Hour of every Night, at the same Place ; whereas, by Means of the Earth's annual Motion, the fixed Stars are disposed into a regular Succession of Appearance, thro' the several Seasons of the Year ; and hereby some Nights are illuminated with a more glorious Hemisphere of Stars than others are. We may add also, that hereby the *stars are made to rule over the seasons of the year*, which may, possibly, come into the Sense of the Text ; for it was a usual Thing with the Ancients, to distinguish the different Seasons of the

Year, by the Stars which rise and appear at those Seasons. Thus in *Job xxxviii.* 31, 32. we read of *the Season of Mazzaroth*; and of *the sweet Influences of Pleiades*, meaning, I suppose, the Spring Season, when that Constellation rises and appears above the Horizon; and also of *the bands of Orion*, by which I understand the Winter Season, when the Earth and Waters are often bound up, as it were, by the Frost. But whether by those two Hebrew Names, *Chimab* and *Chefil*, were meant both the same Constellations, which we now call *Pleiades* and *Orion*, may admit of a Doubt. However, it is certain, that the successive appearing of the fixed Stars, some at one Season of the Year, and some at another, is occasioned by that Motion of the Earth, which our Hypothesis supposes it received on the fourth Day.

Ver. 17th and 18th are nothing but a Repetition of what was said before, such as is very common in the Hebrew Writings; and of which sort a Multitude of Instances might be readily produced from the several Books of the Old Testament.

Thus will the Motions of the Earth and Moon, in their proper Orbits, completely answer all the Phænomena of the fourth Day's Work of Creation; and we easily perceive how God, by giving the Earth and the Moon their orbicular Motions on
that

that Day, made the two great Lights, *viz.* the Sun and Moon, to serve all the Purposes which are there mentioned. Probably, therefore, that was the very Work of the fourth Day.

This Hypothesis perfectly reconciles the Mosaic Account of the Creation with true Philosophy; and without putting any harsh or unnatural Sense on any of the Words and Phrases.

If it should be objected, that the true Motions of the Earth and Moon, which we suppose are referred to in this Account of the Creation, were not known so early as *Moses's* Time, nor till several Ages after; it may be sufficient to answer, That *Moses* wrote this Account by Inspiration of the Spirit of God, who was perfectly acquainted with these Things: And it does not follow, that because *Moses* wrote it, he therefore understood it himself; for the Prophets did not always understand the meaning of their own Prophecies; as appears from 1 *Pet.* i. 11. *The Prophets—searching what, or what manner of Time the Spirit of Christ which was in them did signify, &c.*

One cannot sure suppose, that this Account of the Creation was designed to teach the *Israelites* (who were a poor labouring People, but lately come from working at the Brick-kilns) such deep Points of Philosophy,

losophy, as the true Motions of the Earth and Moon; but rather it was designed to teach them to reverence the great Creator of all Things; and also to preserve them from the Idolatry of the Heathen Nations around them, who worshipped the Sun and Moon, and other Creatures which God had made. But yet, as this Account was wrote by Inspiration, we must suppose it is all agreeable to Truth, and to the Nature of Things. And the Skill of the Divine Author is in this truly admirable, that the Account of the Creation is here given, for the Use of the People, in such Words and Phrases as were suited to the vulgar Conceptions; and yet it is at the same Time perfectly consistent with true Philosophy.

Upon the Whole then, according to this Hypothesis, it may appear that the first Chapter of *Genesis*, instead of meriting that Contempt which some Men have cast upon it, deserves rather to be esteemed, not only as the most antient, but as the most truly philosophical and beautiful Account of the Creation, that ever was published in the World.

A N





I N D E X

To the principal Matters ; and to
the Terms used in *Astronomy*
and *Chronology*, which are ex-
plained in this Book.

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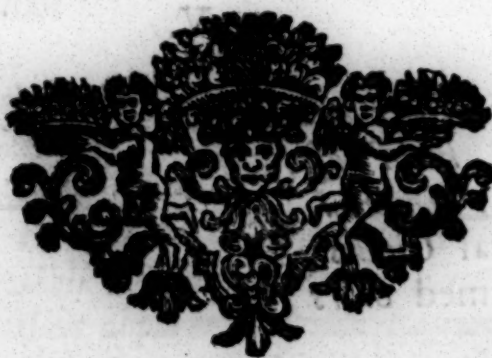
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